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MONOGRAPH OF THE GENUS MONARDELLA[1, 2]

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Introduction

The following paper records the results of a study of the species of *Monardella*, a Labiate genus of western North America. The object of this investigation was to ascertain the relationships and geographical distribution of the various elements which constitute this natural group of plants. The work was done mainly at the Missouri Botanical Garden during the years 1922–24, but during its course the collections of the genus at the Field Museum, the National Herbarium, the Gray Herbarium, the Rocky Mountain Herbarium, the Colorado State Museum, the herbaria of the Universities of Colorado, California, and Washington and of Leland Stanford University, Pomona College, the Oregon Agricultural College, and the private herbarium of W. L. Jepson were studied, in part by loan, in part by visit to the places concerned. Reference is not made to all herbarium material examined. Full citation of specimens is given, however, when the citation concerned is of particular historical interest, when geographical ranges are extended, or for other cogent reasons.

The author is indebted to the curators of the herbaria in which material has been studied or from which loans have been made;

[1] An investigation carried out at the Missouri Botanical Garden in the Graduate Laboratory of the Henry Shaw School of Botany of Washington University and submitted as a thesis in partial fulfilment of the requirements for the degree of doctor of philosophy in the Henry Shaw School of Botany of Washington University.

[2] Issued September 28, 1925.

it was only through their considerate coöperation that so representative a collection of the genus was brought together. He is particularly indebted to Dr. George T. Moore, Director of the Missouri Botanical Garden, for the privileges of the splendid library and herbarium of that institution, and especially to Dr. J. M. Greenman whose helpful advice and unfailing courtesy have both aided the progress and added very greatly to the pleasure of the work.

History of the Genus

Michaux,[1] in 1803, described and illustrated a certain plant which he named *Pycnanthemum Monardella*, the habitat of which was said to be the high mountains of Carolina. The corolla was neither described nor illustrated and in an observation at the end of the description it was stated that the plant was of the habit of *Monarda fistulosa* and that neither it nor the species immediately preceding it were strictly congeneric with the other members of the genus to which they were there assigned. The species referred to was *Pycnanthemum montanum* Michx.

Bentham[2] later made use of the suggestion contained in Michaux's comment and established the genus *Monardella*, using for the generic name the specific designation employed by Michaux. He renamed Michaux's plant *Monardella Caroliniana* and included within this new genus the second doubtful species, *Pycnanthemum montanum* Michaux, which was renamed *Monardella montana*, and three previously undescribed plants collected by Douglas in northwestern America, which were named *M. odoratissima*, *M. undulata* and *M. Douglasii*. In describing the renamed species, *M. Caroliniana*, Bentham referred to it the plant described by Michaux and a plant described by Elliott,[3] repeating their descriptions with quotation marks but giving no indication by the customary abbreviation, "v.s.," that he had seen their specimens. On the contrary, he says: "*Pycnanthemum Monardella* Pursh seen in Lambert's herbarium is very similar to

[1] Michaux, A. Flora Boreali-Americana 2: 8, *pl. 34*, 1803.
[2] Bentham, G. Labiatarum genera et species, p. 331. 1834.
[3] Elliott, S. Sketch of the botany of South Carolina and Georgia 2: 81. 1824.

Monarda fistulosa but the corolla is wanting; thus also in Michaux's drawing; I have not seen Elliott's specimen." [1]

Fourteen years later, Bentham,[2] who in the meanwhile had seen additional material not available at the time of the first revision, definitely referred *Pycnanthemum Monardella* Michx., which he had renamed *Monardella Caroliniana*, to synonymy with *Monarda fistulosa* L. and remanded *Pycnanthemum montanum* to the genus to which it had been assigned originally. Considering the extreme paucity and fragmentary nature of the specimens with which he worked and the similarity of the calyces of *Pycnanthemum montanum*, *Monarda fistulosa*, and *Monardella odoratissima*, the previous error is not to be wondered at. As reconstituted in 1848 the genus included four species of closely related plants, namely, *Monardella odoratissima*, *M. undulata*, *M. Douglasii*, and *M. villosa*, nor was a species of *Monardella* as at present known or as known to Bentham, included in any other genus by him. The genus thus described and constituted was accepted by Gray[3] who enlarged it by the publication of six new species and divided it into two sections. Later authors having to deal with the group accepted it in the same sense.

In 1906 Greene[4] reviewed the history of the genus, as outlined above, but went no further than the original monograph of Bentham, and in conclusion made the following statement: "And while later authors have remanded the type of Monardella to an older genus and an older species even, the name has been retained for what is now a large genus of western plants. The viciousness of this method in nomenclature I long ago attempted to point out; and I here, after long delay, propose a new name for the western genus: a name made out of the old *Monardella*, that is *Madronella*. I shall not attempt to transfer more than a portion of the species, but here is a considerable number of them, placing first in order what should be the type of the genus." There followed a list of the species described by Bentham, Gray,

[1] "Species dubia. *P. Monardella* Pursh! in Herb. Lamb. *Monardae fistulosae* simillima est, sed corolla desunt; sic etiam in icone Michauxiana; plantam Elliottianum non vidi."

[2] Bentham, G. in De Candolle's Prodromus systematis vegetabilis **12**: 191. 1848.

[3] Gray, A. Proc. Am. Acad. **11**: 100. 1876.

[4] Greene, E. L. Leaflets of Bot. Obs. and Crit. **1**: 168. 1906.

and Greene, at the beginning of which was the species *M. odoratissima.*

By the phrase "type of *Monardella*" Greene referred to the species *Monardella Caroliniana* which was the first cited by Bentham. Even had Bentham been familiar with the more recent concept of a "type" it is very doubtful that he would have chosen as the type of a new genus a plant which he had not seen and which he termed "species dubia." Furthermore, by reason of the fact that Bentham himself, as early as 1848, and not "later authors," as erroneously stated by Greene, limited the genus as at present understood, and since the genus was accepted in this sense for fifty-eight years without question, the action of the latter is indefensible. It may be further observed that the original complete and expressive generic diagnosis, based upon a few battered plants, is still exactly applicable to the genus which has been enlarged at least fivefold in number of valid species. The adoption of *M. odoratissima* as the generic type-species was a desirable step because it was the first described of the true Monardellas and because it is the most widely distributed of any of the species.

Since 1906 the names *Monardella* and *Madronella* have both been in use to describe the same group of plants, and the species may be found listed under both names in the 'Index Kewensis.' Since the publications of both Bentham and Greene are not readily accessible, no small amount of confusion has been occasioned.

The first subdivision of the genus, as already mentioned, was by Dr. Gray, in 1876, in a synopsis in which he described as one section "*Macranthae laxiflorae nempe floribus in capitulo laxiusculo sat magis minus numerosis: corolla e calyce longe exserta: antherae loculis ovali-oblongis divaricatis: perennes,*" including therein *M. macrantha* and *M. nana,* and a second group "*Densiflorae et multiflorae: calyce ¼ to ⅓ pollicari: antherae loculis brevioribus minis divaricatis.*" These subdivisions were adopted by Briquet[1] in his presentation of the family in 'Die Natürlichen Pflanzenfamilien' under the name *Macranthae* and *Pycnanthae,* a ter-

[1] Briquet, J. in Engler u. Prantl, Die Natürlichen Pflanzenfamilien. IV. 3a. 309. 1896.

minology which was followed by Abrams[1] in his revision of the southern California species of *Monardella.*

Morphology

The Monardellas are either annual or perennial. The annual species are erect, herbaceous plants from six inches to two feet in height, arising from a short tap-root from which spring small lateral rootlets. They are, for the most part, plants of semi-xerophytic habit, the leaves being few, small, rather thick, and variously pubescent. The stems are columnar, obscurely four-angled, slender and branched. The character of the branching is of two kinds, terminal or basal. In the first type as illustrated by *M. candicans* or *M. lanceolata* the branches occur chiefly in the upper axils and are widely divaricate, but ascending, and when in full flower form thus a corymbose group of inflorescences. The second type, as illustrated by *M. Breweri* and *M. exilis,* are branched throughout with the principal branches arising near the base of the stem and ascending more or less parallel to it, being themselves either simple or branched. Both types may be seen in the same species, yet under the ordinary conditions of its habitat a given species is characterized by one type.

The leaves of the annuals show little diversity, being of about the same range of size, lanceolate or oblong, entire, shortly petiolate and spreading, and subcinereous with a short close pubescence or glabrate. The chief exception to this condition is shown by the leaves of *M. undulata.* Here the leaves are ob-lanceolate and markedly undulate or crisped. The venation is pinnate but rather obscure in the annuals.

The stem of the perennials is generally decumbent, occasionally trailing or even somewhat subterranean, as in the case of *M. macrantha.* It is apparently, in many cases at least, a modification of the first stem to be formed, which after flowering dies back only part way to the base. In some species, as in *M. hypoleuca,* the stem may become elongated to several feet, trailing over and supported by brush. The branches arise from the stem, being either distributed along it in a candelabra-like way,

[1] Abrams, L. R. Muhlenbergia **8**: 26–44. 1912.

as often seen in *M. linoides*, or else from a well-defined crown as in *M. odoratissima*. It is evident from the nature of the distribution of the perennial species that the habit is frequently a function of quite varied environmental conditions. Like the annuals, the stem of the perennials is provided with a stout taproot. In old plants the bark, which is smooth and brown, becomes checked and flakes away. The branches are variously pubescent above and glabrate below. They may be either erect, ascending, or decumbent, and either simple or branched, but when branching the secondary branches are short, slender, and seldom fertile. Their habit is more or less characteristic of the species.

As contrasted with the leaves of the annuals, the leaves of the perennials are diverse in form, covering, and size. They may be entire or serrate upon a single plant. In general, however, there is a certain aspect about the leaf which permits its identification with a certain species. In shape they may vary from ovate to oblong, the extremes being, on the one hand, rotund, and, on the other, linear-oblong; they are more frequently petiolate than sessile, the petioles being always short in proportion.

The pubescence of the stem and leaves is equally diverse, being silky-villous, woolly-villous, tomentose or hirsute, canescent or cinereous, or may be very minute but dense, so as to cause a silvery or glaucous appearance. The pubescence is of value in distinguishing subspecies but by reason of its response to the environment must be used with care as a basis for specific differentiation. In general a close puberulence or pubescence is characteristic of the forms of the drier interior, while forms exhibiting a looser, more villous or tomentose covering are to be found in closer proximity to the coast-line. The pubescence of the stem is usually retrorse, but may occasionally point upwards. In a similar way the trichomes of the upper surface of the leaves may point either to the distal or proximal end. This fact has been utilized by Abrams in separating two closely related forms, but from a microscopic examination of copious material it is clear that this character cannot be relied upon to effect other than an arbitrary separation, for it has been observed that in numerous cases the pubescence of the lower part of the leaf may point downward, while that of the upper part may point upwards. At

the same time material from a given locality which is strikingly similar in other respects and hardly to be separated may exhibit both types of pubescence characters as shown by the collection of *M. linoides* made by Purpus on Pah Ute and Argus Peaks. A similar condition has been observed in other mints, as, for example, the coastal forms of *Monarda punctata.*

Yellowish glandular punctations are common upon the leaves of the genus, and in some cases stalked glands may be present. The former are more apparent in some plants than in others, often being obscured by the pubescence. The punctations vary somewhat in dried material, chiefly in the degree to which the leaves become pitted. Their size remains fairly constant with a certain degree of variation in the frequency of their distribution. No use of them has been made herein.

The inflorescence of the genus consists of a compact globose head or glomerule of flowers borne terminally upon the branch and subtended by a series of bracts arranged in more or less opposite pairs. Rarely, two glomerules may be present, a smaller one above the first. This has been observed only in *M. undulata* and in *M. odoratissima.* The flowers are attached by a short pedicel to a small disc-like structure which terminates the branch and which may be considered a foreshortened and modified cyme. Only the outermost flowers are bracteate. The bracts are of an oval or lanceolate shape and appear membranous or foliaceous, with a pinnate venation. They are of especial value in specific diagnosis, since their form and consistency, their size and arrangement relative to the calyces, their venation, and the nature of the margin and pubescence are accompanied by well-marked differences in other parts and within a given group of closely related forms remain fairly constant throughout a wide range of distribution.

In consistency the bract varies from a white papery membranous structure to a fleshy green form hardly separable from the leaves of the stem. In any case the outermost are more likely to be foliaceous than the inner. In some species the bracts are erect and sheathe the cluster of flowers; in some, however, they are partly or wholly reflexed. Few exceed the calyces by more than half their length, and few are shorter than the calyces.

While the venation is ultimately pinnate in all, in some the mid-vein is foreshortened to such an extent that it appears to be wanting, and the lateral veins appear parallel. Frequently the margin, which in most species is firm and green, becomes thin, scarious, and whitened.

The calyx is tubular, in most species one-fourth to one-fifth as wide as long, and bilabiate in most but appearing equidentate on casual examination. The bilabiate condition of the calyx-limb is especially noticeable in the subgenus *Macranthae*. The teeth are somewhat shorter than the width of the tube and narrowly triangular in form. The veins of the calyx are prominent but hardly costate, giving it a striate appearance. While the aspect of the calyx is much the same throughout, a careful study reveals the fact that numerous small differences may be observed and that within the limits to be expected are quite constantly associated with other characters. This is especially true of the arrangement and number of the veins which vary from 10 to 15 in the genus, and the conformation of the calyx-teeth and their margins.

In the simplest case, the veins of the calyx terminate at the apex of each tooth and at the base of each sinus, being ten in number. In calyces with thirteen veins each of the two shallower sinuses is provided with only one vein, while the three additional veins are paired with each of those in the remaining sinuses. In calyces with fifteen veins, in addition to the five veins terminating in each tooth, each sinus is the terminus for a pair of veins. A species characterized by calyces with ten veins will usually show within the same glomerule calyces with eleven veins, rarely with twelve; calyces with typically thirteen veins will be found to vary between twelve and fourteen; those with fifteen will vary to fourteen, rarely less. If a number of flowers from a given species be examined the number of veins in the calyces will be found to center about one of the three modes indicated.

In some species the margin of the tooth, which is ordinarily bordered by a vein, becomes scarious and white and in a single species prong-like.

The pubescence of the calyx is fairly constant but not sufficiently so to offer a means of infallible specific diagnosis in the

case of the perennials. This was shown to be the case by a microscopic study of various closely related forms, judged by other considerations, which nevertheless showed under the microscope a considerable difference in the degree to which certain trichomes might be developed, thus causing an apparent difference in kind when examined with a lens or the naked eye. The character is of value in separating subspecies, however.

In the nature of the corolla the genus presents several differences not readily observed unless subjected to careful examination. The subgenus *Macranthae* is characterized by the unusual proportions existing between the corolla-tube and the limb, on the one hand, and the corolla-tube and the calyx, on the other, as well as the fact that the lobes of the corolla taper evenly to a point. In the case of the subgenus *Pycnanthae*, the corollas are much the same size, the size being nearly constant for a given species, yet present valuable diagnostic indices in the degree to which the lips are lobed and the shape of the lobe. The corolla is definitely bilabiate, the posterior lip being two-lobed, the anterior three-lobed. The lobes are linear-oblong or linear-lanceolate. The shape of the lobes, whether nearly equal throughout and ribbon-like or whether tapering noticeably, whether blunt or whether rounded to a point, and the degree to which they are coalesced, are characters which have been found fairly constant for most of the species and are of help in specific differentiation. The degree of exsertion of the corolla-tube from the calyx is also of value but must be employed with caution. The presence or absence of a retrorse pubescence within the tube at the base of the stamens may be used as a specific character but when present such a pubescence is variable.

The stamens are four in number, the two anterior exceeding the posterior. They are attached to the corolla just within the throat, their position varying but little. The filaments are fairly stout and present little or no difference. They are often retrorsely hispidulous but when this condition is present it is quite variable on the same plant, and not infrequently a single filament may be pubescent nearly to the apex while the remaining three are glabrate.

The anthers and connective and the relation between the two

serve admirably in some cases as characters for specific differentiation, and in the case of *Macranthae* are subservient to subgeneric differentiation. The anther-sacs are two, subparallel or divergent, being subconfluent above when markedly divergent. In the annuals the degree of divergence, which is a function of the development of the connective, is in general less and the connective is less developed than in the perennials. In the former the shape of the anther-sac after dehiscence, together with the appearance of the connective, especially the conformation of its lower margin, was found to be somewhat diverse among the species but constant for a given species. In the perennials, however, the connective presents much the same appearance in all the species, being approximately equilateral when viewed from the front, except in the subgenus *Macranthae* where the angle of divergence approaches that of 180 degrees.

The ovary is four-parted, forming at maturity four smooth brown nutlets, basally attached, oblong or oval in outline and somewhat flattened. These are about two millimeters in length and present few differences. The style is about the length of the corolla, unequally bifid at the top and glabrous.

Considering the genus as a whole, the following morphological criteria have been found most trustworthy in diagnosis of the species: the habit and foliage within certain limits, the texture of the bracts, the number of the calyx-nerves and the form of the teeth, the conformation of the lips of the corolla and the structure of the anthers.

Relationships and General Distribution

The species of *Monardella*, while forming a precisely circumscribed and very natural group as a genus, are not themselves so easily capable of definition. This is particularly true of the perennials, where very considerable degrees of variation may occur on a single individual. In the absence of copious material for study, or through failure to consider variations in connection with their geographical relationships, or by reason of tendencies to magnify differences between individuals while neglecting or overlooking equally important likenesses, many of the variants

which may be found in the perennials have been described as species. If these variants, however, are studied in connection with one another and in relation to their environment and geographical and ecological distribution, the distinctions upon which such species rest will be found to effect no more than an arbitrary delimitation. Considered alone, the type specimens of these species offer quite ample grounds, in many cases, for designation as species. Considered in connection with numerous intergrading and connecting forms, considered as living plants and not as artifacts, followed from one area of occurrence to the next throughout the range as organisms in contact with an ever-changing environment, such variants will be found to merge imperceptibly.

The criteria which had been described above have been found to offer a means of separating the genus into certain groups which are rather clearly defined, and which have a characteristic and natural distribution, and which suggest at the same time a probable phylogenetic sequence. These groups have been termed species and in general correspond to the concept known as the Linnaean species, a category of great value in demonstrating ecological, geographical and morphological relationships.

To insist that such a category is homogeneous would doubtless lead to error in numerous cases and is contrary to well-known evidence; to ignore the variations which occur within such a group would serve only to prevent a further understanding of it; to recognize that such a group may be heterogeneous but nevertheless that its members are more closely related to each other than to the other members of the genus and to so name these elements that the relationship may be apparent in the name, just as the relationship between species is indicated in the common generic name, has seemed to the writer the most helpful course in the case of the genus *Monardella*.

To determine the exact relationship existing between the elements of a species requires detailed analytical and synthetical experiment. Such a course has not been possible in the present study. Proceeding on morphological grounds an attempt has been made to characterize the components of the polymorphic species in so far as these components appear to represent certain evo-

lutionary tendencies within the species. Such categories have been termed subspecies, in the sense that the groups thus designated merge imperceptibly, but when taken in the average or typical aspect occupy a definite and characteristic habitat. It is not without caution that the term subspecies has been thus employed in the absence of genetical data and garden observation and experiment. By way of illustration it may be assumed that the several subspecies comprising the species *M. villosa* are derived from a common stock which was at one time in occupancy of the approximate area now occupied by the species. By reason of isolation, or through climatic changes in geological time, or for other reasons, the species once homogeneous may be thought of as gradually differentiating into several closely related groups, each with a characteristic habitat. These groups would form the subspecies herein described, each exhibiting a tendency of evolution from a common stock, which might very well be still extant. Such subspecies do not vary merely by the presence or absence of a single given character, but rather in the accumulation of numerous small differences. The category known as the variety has been employed to designate those forms which differ from the typical, principally in the presence or absence of one or two morphological characters of the magnitude commonly employed in taxonomy. Such forms, as herein understood, do not possess a characteristic geographical or ecological distribution distinct from the typical. It has been possible thus far for the writer to bring only *M. odoratissima* under cultivation. From the behavior of other *Labiatae* grown from seed or from transplants from the field, particularly of the genus *Monarda*, it is believed that the subspecies as herein described will be found to be racially distinct and not impossibly a complex of variants which differ genetically, the subspecies representing the modal points of such a complex.

Related groups.—Each of the four most widely distributed species, *M. macrantha*, *M. lanceolata*, *M. villosa*, and *M. odoratissima*, may be considered a center about which the other species can be arranged according to resemblances. Four species, three of which are endemic, are more or less intermediate or of uncertain relationship. The groups resulting from such an arrangement are herein designated as "Sections" and are as follows:

Section I

M. macrantha
?*M. Palmeri*

Section II

M. lanceolata
M. Breweri
M. Pringlei
M. leucocephala
M. candicans
M. exilis
M. Douglasii
?*M. undulata*

Section III

M. villosa
M. lanata
M. hypoleuca
M. viridis
M. saxicola
?*M. cinerea*
?*M. thymifolia*

Section IV

M. odoratissima
M. linoides

The sections are all closely connected, yet the greater and more significant differences of the first, as contrasted with the remaining three, have led to its segregation as the subgenus *Macranthae*. *M. Palmeri* is apparently an intermediate form. Of the remaining three sections, the second, while closely knit and showing definite lines of divergence, is still too closely connected with the other two to be separated as a subgenus. A brief comparison of the morphology of each of these groups will be made in order to indicate the possible affinities. The conclusions drawn from such a comparison are shown in fig. 1.

The habit of the subgenus *Macranthae* is not essentially different from that of the subgenus *Pycnanthae* but the stem is slender and more or less rhizomatous and semi-subterranean, giving rise to either decumbent or ascending branches, usually few in number and located at the distal end. In those forms which occur in acerose forests the stem trails along beneath the detritis of the surface layer. In the forms of more xerophytic habit this distinction is partly lost, and in *M. macrantha* var. *arida*, the variety most adapted to a xerophytic habitat, a definite crown is formed and the branches often rebranch at the base, thus forming a small tuft: the habit, in other words, of the subgenus *Pycnanthae*. It may be said, then, that there is a tendency on the part of the most restricted of the species of this subgenus to assume the growth-form which characterizes the perennials of the subgenus *Pycnanthae*. *Macranthae* are further characterized

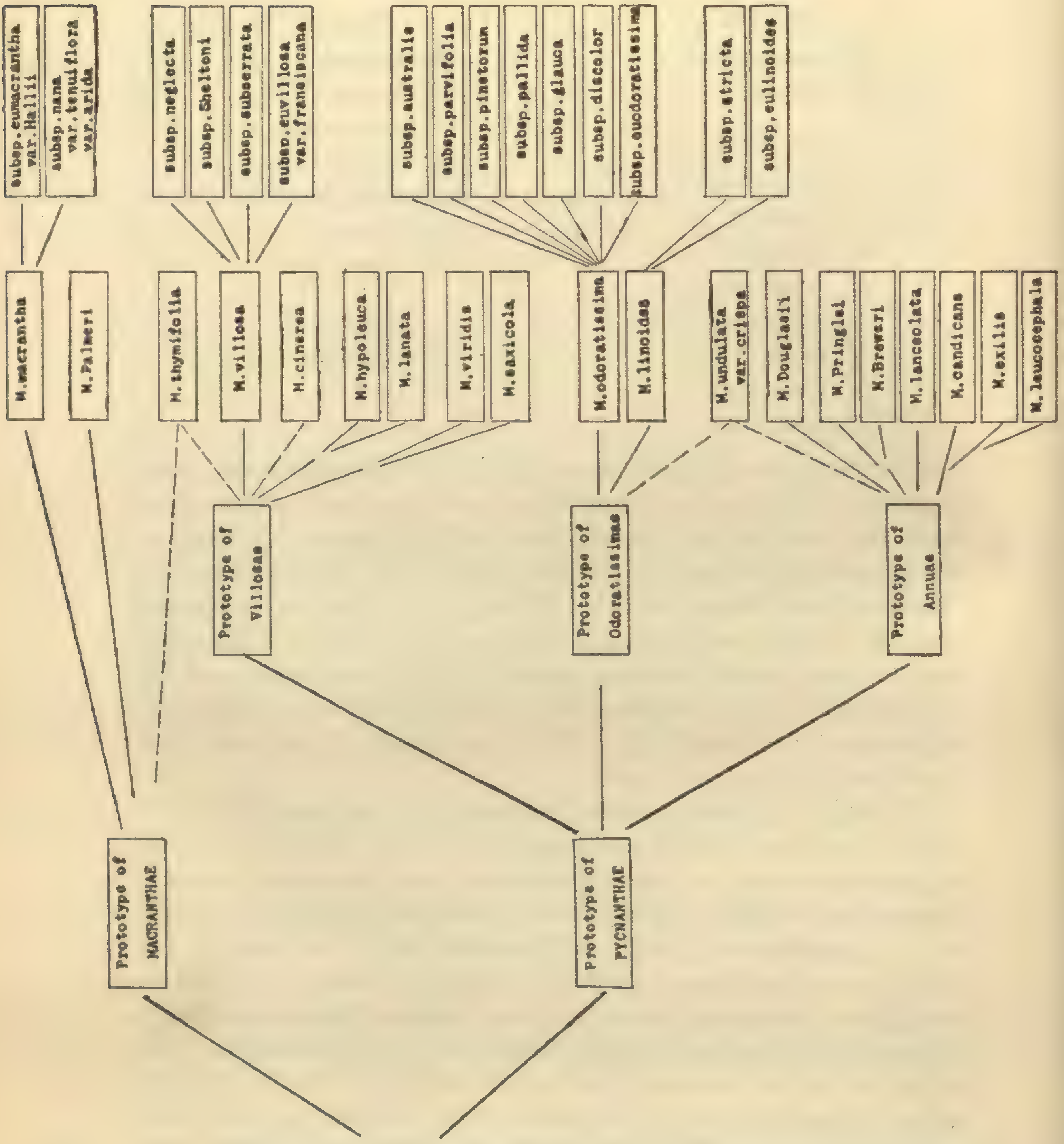

Fig. 1. Diagram of relationships.

by a more coriaceous leaf than is generally the case in *Pycnanthae*. In form and size of leaf there is great diversity within the group, even on individual plants, yet all are united by the possession of a hardly definable aspect which suggests a common relationship.

In addition to the vegetative habit, the habit of the inflorescence is distinctive. While fewer-flowered, given equal opportunity for development, the inflorescences in *Macranthae* are larger in proportion to the plant, due in part to the larger calyx and corolla, and give a top-heavy appearance to the branch in typical cases. The arrangement of the flowers in the glomerule is also looser. However, the greatest difference between the two subgenera lies in the flower. The calyx is actually larger in *Macranthae* and different in proportion, and the corolla is of different proportions, although in the more reduced forms a casual glance would not distinguish it from the corolla of *M. villosa* for example.

A study of the corolla indicates either a progressive reduction from the large corolla of *M. macrantha* subsp. *eumacrantha* to the small corolla of subsp. *nana* var. *arida*, or a progressive development in the other direction. It is believed by the author that the series is a reduction series; first, because the vegetative habit of the small-flowered species is correspondingly reduced and adapted to the arid habitat; second, the corollas themselves strongly suggest a reduction form, whence the specific adjective; again, in the progressive color changes which accompany the reduction in size certain characters are lost rather than gained.

In resumé, then, we may state that *M. macrantha* is the least modified of the species of the first subgenus and hence most like the hypothetical common precursor of the two subgenera. *M. Palmeri*, a restricted endemic, is intermediate between the subgenera. There may be observed in the subgenus two evolutionary tendencies, namely, the adoption of a more compact growth-form and a reduction and modification of the flower and foliage, both attendant upon occurrence in a more arid habitat.

The annuals form a well-defined and interesting group. They are all of essentially the same stature, growth-form, and foliage, except *M. undulata*, and differ principally in the characters of the inflorescence, namely, in the texture of the bracts and in the degree to which the corolla is bilabiate. By reason of the fact that *M. lanceolata* is least differentiated, it is looked upon as being most like the common progenitor of the annuals. From this basis it is possible to trace three suggestive lines of divergence. The first to be considered will be that of the bract.

As previously stated, the bract of *M. lanceolata* is less differentiated and not infrequently becomes foliar in nature. It is lanceolate, acute, pinnately veined, green and opaque, but not fleshy. Beginning here one may trace through *M. Breweri*, *M. Pringlei*, *M. candicans*, *M. exilis*, and *M. leucocephala* a progressive reduction of the midvein until the veins appear parallel, apparently arising from the base of the bract, but in reality from a much foreshortened mid-vein. More or less concurrent with the reduction of the midvein is a reduction of the secondary veins, as well as an increasing scarious nature of the bract. In the opposite direction lies a very curious effect. In *M. Douglasii* the midvein and secondary veins have become costate and thickened, the latter becoming confluent on the margin. The intravenous tissue has become homogeneous, translucent or even transparent, and tough, suggesting isinglass. While this would appear an extreme modification it should be noted that in many instances half of the bract may be truly foliar.

Correlated with the differentiation of the bract is a differentiation of the corolla. In *M. lanceolata* the corolla is bilabiate, the lobes of the upper lip being coalesced for two-thirds of its length, the lobes of the lower lip being free nearly to the base. A progression may be observed commencing with *M. lanceolata* through *M. candicans*, *M. Breweri*, *M. Pringlei* to *M. exilis* and *M. leucocephala* in which the corolla-lobes become more coalesced until those of the upper lip are free for less than a quarter its length while those of the lower lip are coalesced for about one-third of its length. At the same time the corolla becomes less and less exserted until in *M. leucocephala* it is hardly seen at a casual glance.

Again, the calyx-teeth of *M. lanceolata* are green, lanceolate and acute. In *M. Breweri* and *M. Pringlei* the calyx-teeth are herbaceous still, but slender and not infrequently become slightly mucronate. In *M. candicans* they are herbaceous but frequently scarious-margined. In *M. exilis* the scarious margin is well developed and conspicuous. In *M. leucocephala* the calyx-teeth are terminated by a whitened recurved prong. It should be observed that each of these lines of development is correlated with occurrence in a more arid habitat, and since the plants are annuals, presumably with a shortened vegetative cycle.

M. undulata is a variable species of uncertain relationship, annual in part, suggesting the annuals in some respects, in others more closely allied to *M. odoratissima.* The oblanceolate crisped leaf is unique in the genus.

We may conclude, then, that the annuals of the subgenus *Pycnanthae* form a natural closely knitted group, showing increased adaptation to a more arid habitat. Three correlated lines of divergence may be observed, namely, a progressive modification of the bract, of the corolla and of the calyx. *M. undulata* is of uncertain relationship but lies closest to this section.

The perennials of *Pycnanthae* may be divided rather arbitrarily into two sections by the nature of the bract, whether firm and tending to foliar, or whether membranous. In addition the corolla of the latter group is generally more bilabiate, the upper lip being coalesced to a greater extent than in the former. The first section is typified by *M. villosa,* the second by *M. odoratissima. M. villosa* is regarded as being the least modified of any of the species of this subgenus by reason of the subfoliar nature of the bract, the slight degree to which the lobes of the corolla have become coalesced, the bilabiate condition thus being less pronounced, and because of its generally more mesophytic character. The occurrence of broadly ovate, obtuse, crenate-dentate hairy leaves suggests strongly a relationship to *M. macrantha* var. *Hallii.* Such a conclusion is strengthened by a comparison of the leaves of the endemic *M. thymifolia* which occurs on Cedros Island off the coast of Mexico. Facts of distribution support the assumption that these three species (*M. villosa, thymifolia, macrantha*) taken together indicate the probable nature of the generic prototype.

Section III, as outlined above, is united by the perennial habit, by the rhomboidal crenate-dentate leaves, in general glabrate above and variously tomentose beneath, by the subfoliar or thickened bract, and the little modified corolla. *M. hypoleuca, M. lanata, M. viridis* and *M. saxicola* more nearly resemble each other than they resemble *M. villosa. M. cinerea* and *M. thymifolia* are endemics of uncertain position but most nearly related to *M. villosa.* The latter suggests the subgenus *Macranthae* in the aspect of its foliage. The former suggests *M. odoratissima*

in bract character and habit. *M. odoratissima* and *M. linoides*, while more closely related to each other, are nevertheless very close to this section. They have been grouped separately, partly for convenience in illustrating their distribution. Sections III and IV are more heterogeneous than the two preceding and it is more difficult to discern any continuous line of development in them. In general it is true that, with an increasing occurrence in an arid habitat, the leaves progress from ovate and crenate to oblong or oblong-linear and entire and become more thickened and leathery; the bracts from foliaceous become membranous or chaffy; the lobes of the corolla become more coalesced.

A study of the genus as a whole suggests strongly that it is a genus of mesophytic origin which exhibits an increasing adaptation to an arid habitat.

Distribution.—Generally speaking it may be said that Section I occupies the mountains of southern California and northern Lower California; that Section II occupies the less arid parts of the interior valley of California; that Section III occupies the coast ranges of California and southern Oregon, while Section IV occupies the high mountains surrounding the Great Basin. The more detailed distribution may be better obtained by reference to the accompanying charts than from a verbal description here.

In view of previous discussion relating to isolation as a factor in the origin of species[1] it is desired to call attention to an apparent correlation between the degree of relationship existing between certain components of the genus and the degree to which these components are associated geographically.

The species in which the widest range of variability is found and in which the units are least readily defined is *M. macrantha*. It is also a species of considerable geographical range, extending as it does from the Santa Lucia Mountains, near the Monterey peninsula to San Pedro Martir in Lower California. The variations in foliage and pubescence are considerable but are surpassed by

[1] Jordan, D. S. The origin of species through isolation. Science N.S. **22:** 545–562. 1905; Lloyd, F. E. Isolation and origin of species. *Ibid.* 710–712. 1905; Abrams, L. R. Theory of isolation as applied to plants. *Ibid.* 836–838. 1905; Abrams, L. R. and Smiley, F. J. Taxonomy and distribution of Eriodictyon. Bot. Gaz. **60:** 115–133. 1915.

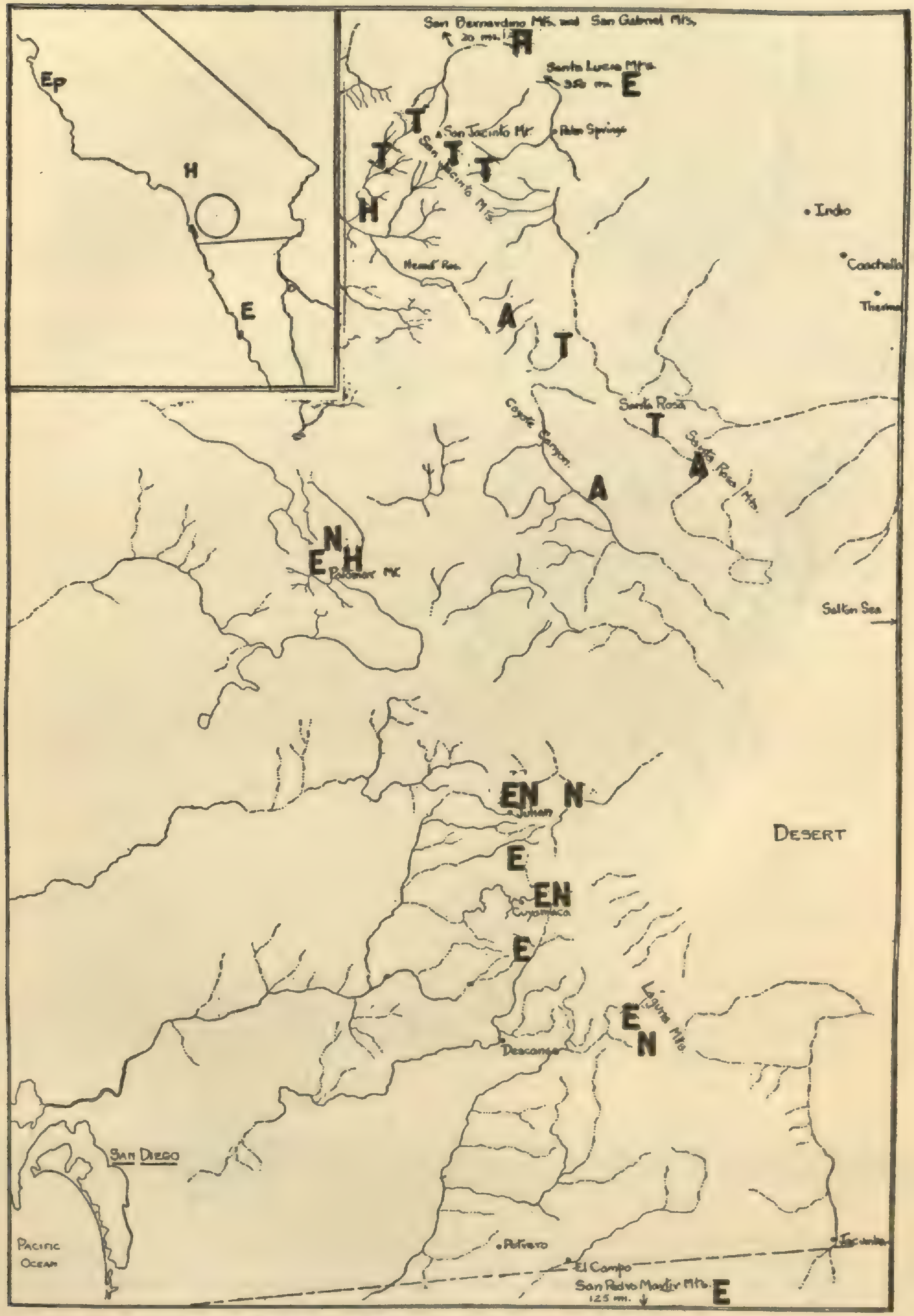

Fig. 2. Map of San Diego County, California, with an insert of southern and Lower California, showing the distribution of *Macranthae;* E, subsp. *eumacrantha;* H, subsp. *eumacrantha* var. *Hallii;* N, subsp. *nana;* T, subsp. *nana* var. *tenuiflora;* A, subsp. *nana* var. *arida;* P, *M. Palmeri.*

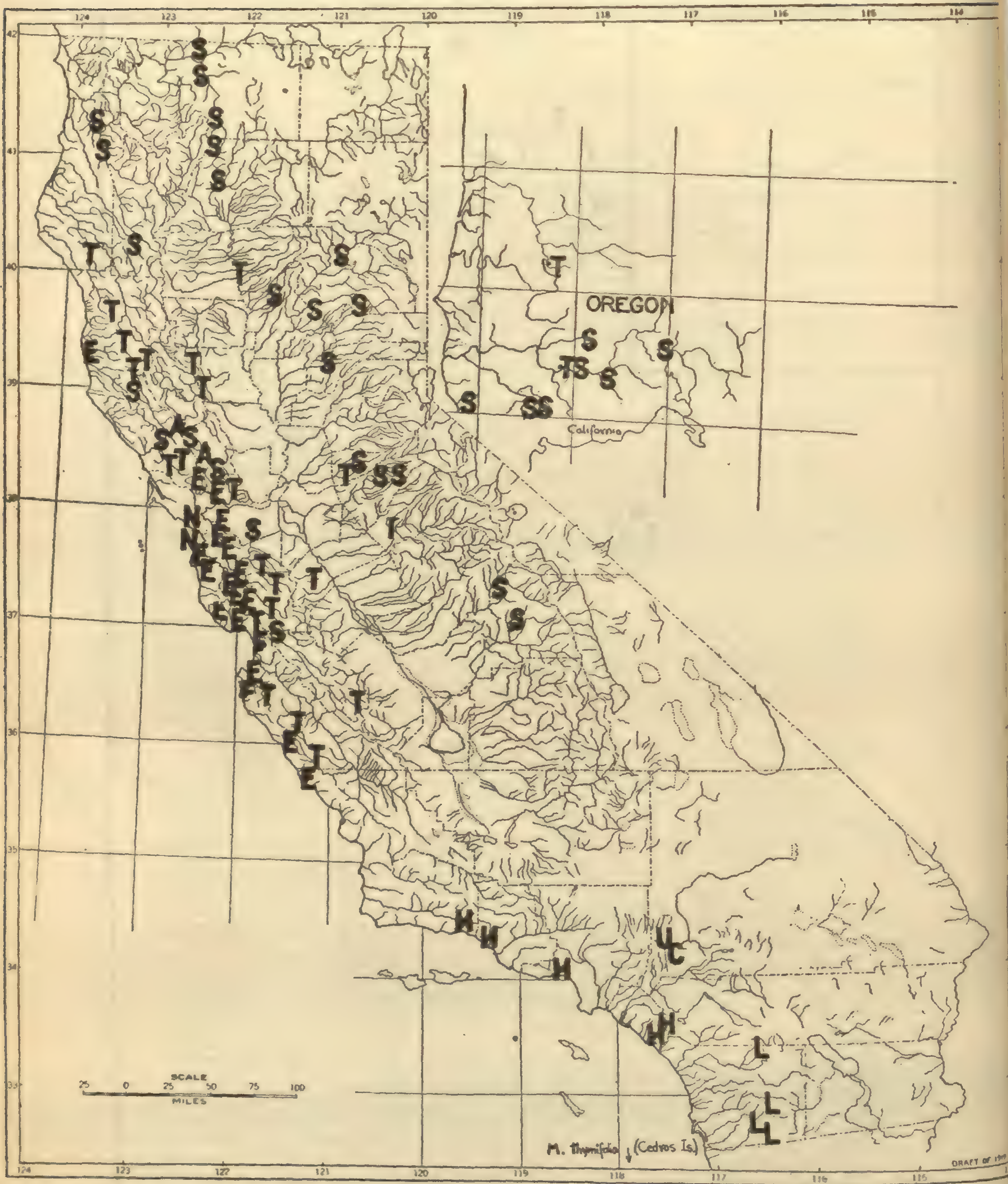

Fig. 3. Map of California and adjacent Oregon (insert), showing distribution of *M. villosa* and allied species: E, *M. villosa* subsp. *euvillosa;* N, *M. villosa* subsp. *neglecta;* S, *M. villosa* subsp. *Sheltoni;* T, *M. villosa* subsp. *subserrata;* H, *M. hypoleuca;* L, *M. lanata;* A, *M. viridis;* U, *M. saxicola;* C, *M. cinerea.*

the variations in corolla size. It was pointed out by Gray[1] and more recently by Hall[2] that, although the extremes in corolla size within the group are most diverse, they are connected by a continuous and graded series. As far as the size is concerned this is true, but as shown by Abrams[3] there is apparently a certain qualitative difference present, namely, the shape of the corolla-tube, as well as a slight quantitative difference in the size of the anther. These differences are correlated with differences in foliage and pubescence so that two fairly well-defined groups may be discerned. These groups were both given specific rank by Gray (as *M. macrantha* and *M. nana*) who later, with the accession of more material reversed his opinion. They were considered distinct species by Abrams. Whether called species or subspecies or varieties, the two groups are very closely connected morphologically and are very closely associated geographically. The group designated herein as subsp. *eumacrantha* is found in the Santa Lucia Mountains, the San Gabriel Mountains, the San Bernardino Mountains, and the mountains of Lower California at San Pedro Martir. In addition it is found in the San Jacinto Mts. at low elevations and in San Diego County on Palomar Mt., in the mountains near Julian, in the Cuyamaca Mountains and in the Laguna Mountains, but in these places is in association with the group designated herein as subsp. *nana*, both forms apparently occurring in the same locality.

The subspecies *nana*, on the contrary, is confined largely to the mountains of San Diego County, occurring in the typical aspect only in the localities in which is also found subsp. *eumacrantha*. The possible exception may be found in the Orcutt collections at Japa in Lower California. The author has been unable to ascertain the location of this place. While being always associated with subsp. *eumacrantha*, when in typical aspect, subsp. *nana* exhibits two fairly well-defined varieties which together have a separate geographical distribution, being found in the San Jacinto and Santa Rosa Mountains at higher elevations.

[1] Gray, A. Syn. Fl. N. Am., ed. 2, 2^1: 459 (suppl.). 1886.

[2] Hall, H. M. A botanical survey of San Jacinto Mountain. Univ. Calif. Publ. Bot. 1: 109. 1902.

[3] Abrams, L. R. The Monardellas of southern California. I. Muhlenbergia 8: 26. 1912.

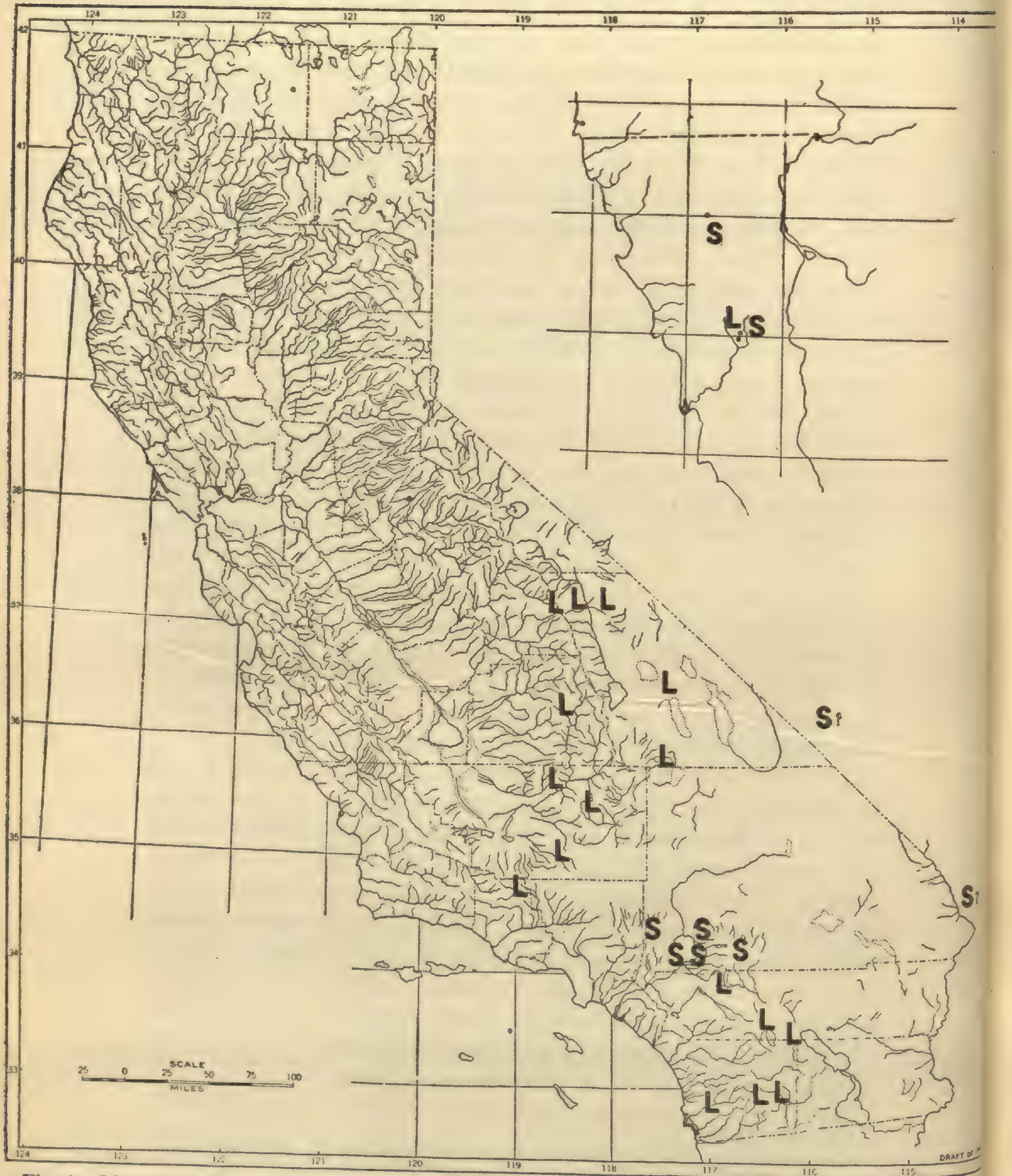

Fig. 4. Map of California and adjacent Lower California (insert), showing distribution of *M. linoides:* L, *M. linoides* subsp. *eulinoides;* S, *M. linoides* subsp. *stricta.*

Since subsp. *nana* and its varieties *tenuiflora* and *arida* are almost certainly derivatives of subsp. *eumacrantha* or a similar form now extinct and since the relationship is still very close it is of interest to find that the range of the former subspecies coincides with a limited portion only of the range of the latter subspecies and of particular interest to note that the chief deviation from the range of subsp. *eumacrantha* is found in the two most highly adapted varieties, namely, var. *tenuiflora* and var. *arida*.

The section which is next in order in the closeness of the relationships of its components is section IV, composed of *M. odoratissima* and *M. linoides*. This group is also of the widest geographical distribution. As treated herein the first-named species is divided into seven subspecies, the second into two subspecies. In actuality the group represents an almost unbroken series of intergrading forms, with but a poorly defined hiatus between *M. linoides* and *M. odoratissima*. While the extremes within *M. odoratissima* are much less than in *M. macrantha*, nevertheless the modal points within the range of variation stand out more clearly than is true of the varieties and subspecies of that species. These modal points furthermore represent plants with characteristic geographical habitats which are distinct but contiguous. It is chiefly in the intermediate geographical regions that intermediate morphological forms are found. The same is true in the case of *M. linoides*.

M. villosa and its allies present a condition where differentiation has proceeded further, where the connecting forms have disappeared and where the related species are separated by definite and sometimes considerable geographical barriers. At the same time there is occurring in *M. villosa* the same differentiation with respect to geographical habitat which has apparently taken place in the formation of this species and its allies. *M. villosa* extends from northern San Luis Obispo County to southern Oregon, never being found east of the Sierra Nevada as far as known. Its subspecies intergrade but occupy characteristic and contiguous geographical habitats. Just as in *M. odoratissima*, the intermediate morphological forms are intermediate geographically. The only other ally which is found in this range is *M. viridis*. *M. viridis*, however, is most nearly connected to *M. saxicola* which is found

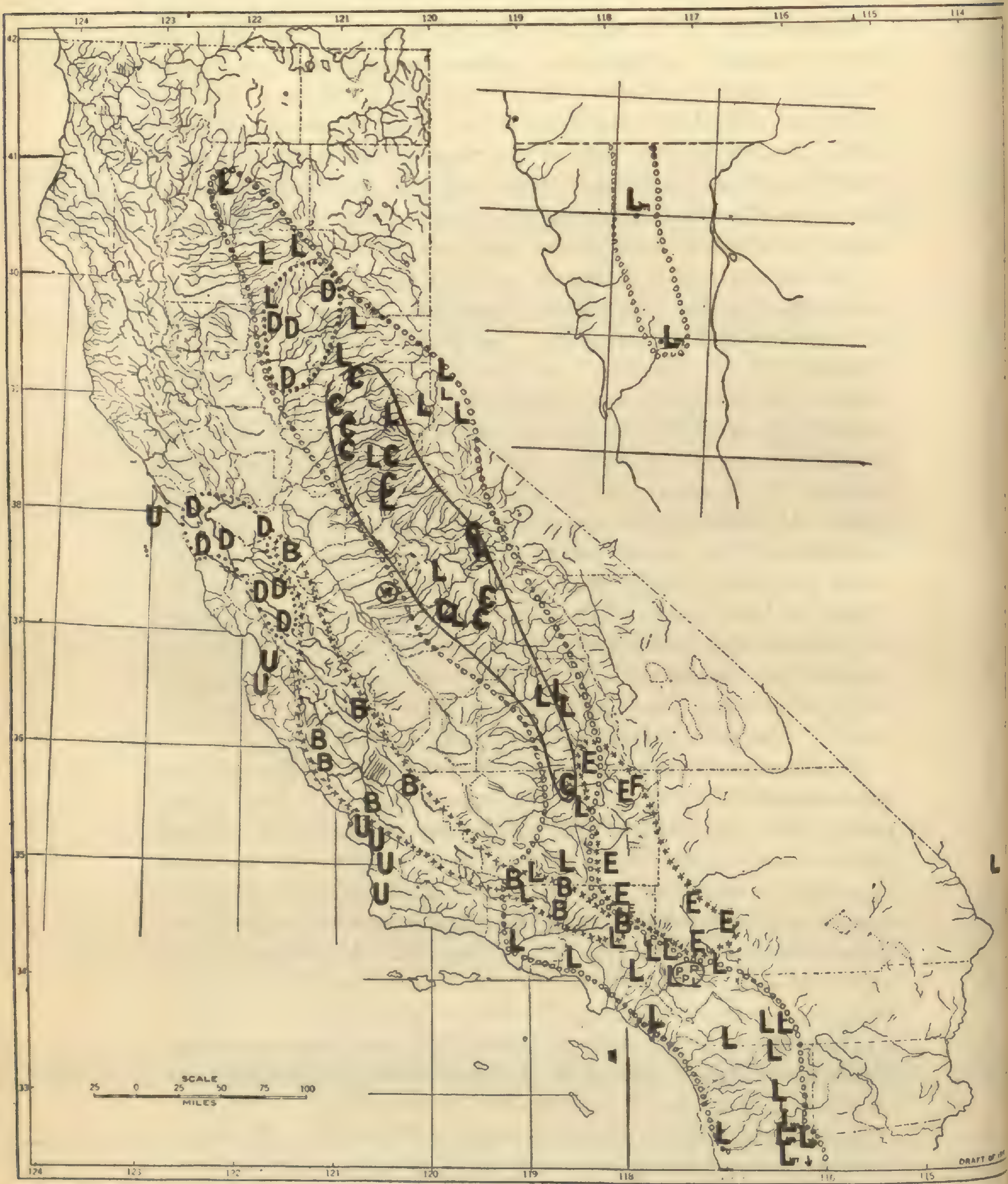

Fig. 5. Map of California, with an insert of a portion of Lower California, showing the distribution of t
annuals: L, *M. lanceolata;* Lm, *M. lanceolata* var. *microcephala;* B, *M. Breweri;* C, *M. candicans;* E, *M. exilis;*
M. Pringlei; W, *M. leucocephala;* D, *M. Douglasii.*

in the San Gabriel Mountains. *M. lanata* and *M. hypoleuca* are more closely connected to each other than to any other species. *M. cinerea* and *M. thymifolia* are species of uncertain relationship, but most nearly allied to *M. villosa.* They are very restricted in distribution, the former being found only on Mt. San Antonio (Mt. Baldy) in southern California, the latter on Cedros Island off the coast of Lower California.

The same situation exists in the case of the annuals and is even more clearly seen there. As already stated it appears that *M. lanceolata* is most nearly like that prototype from which these species have evolved. It has also the widest range, from Lower California to the Tehachapi, thence along the Sierra Nevada to Shasta County. Within this range are also to be found the distributional areas of three other species which are themselves clearly separated. With the exception of this overlapping on the part of *M. lanceolata*, the ranges of the other allied species, seven in number, are distinct. Of these, two, namely, *M. leucocephala* and *M. Pringlei*, are very restricted in distribution, the former being found on the plain of the San Joaquin River near Merced, the latter in the Jarupa Hills near Colton. The areas of distribution of all the species save *M. Douglasii* appear to be continuous. In the case of this species, however, one area in the Coast Range and foothills of the Bay Region is separated from the second in the foothills of the Sierra in Yuba, Butte and Plumas Counties by the valley floor of the Sacramento River. There was found no apparent morphological difference between the inhabitants of the two regions. One specimen of *M. lanceolata*, very typical in aspect, was found to have been collected in "Mont. Cr." Arizona. The location of this place could not be ascertained. If the label was correct this would represent an unusual extension of the species. *M. undulata*, which is most nearly allied to the annuals, is confined to the coastal hills ranging from Santa Barbara County to Point Reyes. There is nothing to suggest that its area of distribution is not continuous.

It is apparent from the facts presented above that there does exist in the genus *Monardella* a correlation between the degree to which its components are related and the degree to which they are separated geographically. It is strongly indicated that such

groups of species as the annuals or the allies of *M. villosa* have arisen from a common stock which was at one time in possession of the territory now occupied by the group as a whole and that such species were formed after isolation of the chief variants within this common ancestor. It is not inconceivable that even moderate climatic changes on the Pacific slope would effect a similar segregation of the subspecies of *M. odoratissima* into forms which, after a period of isolation, would appear as distinct species of distinct range.

Center of dispersal.—Adams,[1] adopting suggestions from previous authors, has proposed the following criteria for the determination of centers of dispersal, in the absence of paleontological evidence:

"1. Location of greatest differentiation of type.
2. Location of dominance or greatest abundance of individuals.
3. Location of synthetic or closely related forms (Allen).
4. Location of maximum size of individuals (Ridgway-Allen).
5. Location of greatest productiveness and its relative stability, in crops (Hyde).
6. Continuity and convergence of lines of dispersal.
7. Location of least dependence upon a restricted habitat.
8. Continuity and directness of individual variations or modifications radiating from the center of origin along the highways of dispersal.
9. Direction indicated by bio-geographical affinities.
10. Direction indicated by annal migration routes, in birds (Palmén)."

More recently Livingston and Shreve[2] have modified these somewhat and have suggested the following as further criteria applicable to plants:

1. Location of most rapid rate of growth.
2. Location in which a form is accompanied by the largest number of individuals which are specifically distinct but of the same growth form.

In the present case it has seemed desirable to restate these criteria and to limit the group under immediate consideration to

[1] Adams, C. C. Southeastern United States as a center of geographical distribution of flora and fauna. Biol. Bull. **3**: 115–131. 1902.

[2] Livingston, B. E. and Shreve, F. The distribution of vegetation in the United States as related to climatic conditions. Carnegie Inst. Wash. Publ. 284: 392. 1921.

one showing close affinities and a common growth-form. In the case of *Monardella* it seems not improbable that the annual species have had a more recent origin than the perennial stock; if this is true the center of dispersal need not necessarily coincide with that of the perennial species. Since the annuals form a natural group of close affinity the criteria were applied to them separately. The species were considered units. Each of the groups of perennials outlined above was similarly treated. By means of such integration a closer approximation may be had to the center of dispersal of clearly related categories. If the centers of dispersal of such categories coincide, greater confidence may be felt in stating the center of dispersal for the larger group. At the same time secondary centers of dispersal may be disclosed which would otherwise lie hidden.

CRITERIA FOR DETERMINATION OF A CENTER OF DISPERSAL.

Determination of:

1. Region inhabited by the most units of the category studied.
2. Region inhabited by the units which are most diverse morphologically.
3. Region indicated as the focus of geographical paths of dispersal.
4. Region indicated as the center of dispersal of the units least modified.
5. Region where the most units are most successful as judged by:
    a. greatest abundance of individuals,
    b. greatest reproductive activity,
    c. greatest vegetative vigor,
    d. least dependence upon a restricted habitat.
6. Region indicated by known center of closely allied categories.
7. Region indicated as the center of evolutionary tendencies in development as shown by progressive modification or increasing adaptation to a certain habitat.

These criteria were applied independently to the four sections outlined in preceding paragraphs. Since the application of certain of these criteria presupposes a field study it was impossible to

draw any conclusions regarding these. A more extensive study of the species in the field, following the lines of variation of each species, is necessary for a satisfactory solution. From the conclusions which it was possible to draw it would appear that the present center of dispersal of *Monardella* lies in California south of the 35° parallel. There appear to be two subordinate centers, each of which corresponds to the center of distribution of a subgenus: *Macranthae* centering in the mountains of San Diego County, *Pycnanthae* in the mountains and foothills of Los Angeles and Ventura Counties. The results obtained are shown in table I.

It is generally believed that the western margin of the North American continent had assumed substantially its present outline by the beginning of the Eocene,[1] which was marked by a tropical or subtropical climate as far north as Puget Sound.[2] With the Pliocene began a period of elevation of the continental margin which reached its climax during the glacial period of the Pleistocene, followed by a subsidence to somewhat less than its present elevation.[3] These movements and attendant climatic changes affected profoundly the existent flora and fauna which by this time had assumed a distinctly modern type.[4] There seems to be evidence that in western North America the increase in elevation varied at different times from 1500 feet along the coast[5] to 3000–6000 feet in the Sierra and Cascade Ranges and in the interior basin.[6]

An abundant precipitation and a corresponding increase of snowfall resulted in an extensive glaciation which reached southward along the Cascade Range into southern Oregon and the Sierra Nevada of California and was also present in the Rocky Mountains and the Wasatch Range of Utah.[6, 7, 8] This, the so-

[1] Schuchert, C. Paleogeography of North America. Bull. Geol. Soc. Am. **20**: 427–606. 1910.

[2] Smith, J. P. Salient events in the geologic history of California. Science N. S. **30**: 346–351. 1909.

[3] Salisbury, R. D. Physical geography of the Pleistocene with reference to the correlation of Pleistocene formations. In Willis & Salisbury, Outlines of Geologic History. 306 pp. 1910.

[4] Osborn, H. F. The age of mammals. 635 pp. 1910.

[5] Salisbury, R. D. *l. c.*

[6] Smith, J. P. *l. c.*

[7] Russell, I. C. Geological history of Lake Lahontan. U. S. Geol. Surv. Monogr. **11**: 1–288. 1885.

[8] Gilbert, G. K. Lake Bonneville. U. S. Geol. Surv. Monogr. **1**: 1–438. 1890.

TABLE I

A CHART SHOWING RESULTS OBTAINED BY APPLICATION OF CRITERIA TO DETERMINE A CENTER OF DISTRIBUTION

Criterion	Section I	Section II	Section III	Section IV
	Unit: subspecies	Unit: species	Unit: species	Unit: subspecies
1. Greatest number of units	Palomar-Santa Rosa Cuyamaca	San Gabriel-San Bernardino	S. W. California	San Gabriel–San Bernardino
2. Most diverse units	Palomar-Santa Rosa Cuyamaca (*M. macrantha Hallii* and *M. macrantha arida*)	Bay region (*M. Douglasii* and *M. leucocephala*)	S. W. California (*M. cinerea* and *M. hypoleuca*)	San Gabriel-San Bernardino
3. Focus of geographical avenues of dispersal	Not determined	San Gabriel	Not determined	San Gabriel
4. Center of dispersal of unit least modified.	Cuyamaca region (*M. macrantha eumacrantha*)	? San Gabriel (*M. lanceolata*)	Bay region (*M. villosa euvillosa*)	Not determined
5. Most units most successful: a. vegetative vigor b. reproductive vigor c. least restricted habitat	a. Palomar-Santa Rosa Cuyamaca b. Not determined c. Not determined	a. San Gabriel-San Bernardino b. Not determined c. Not determined	a. S. W. California b. Not determined c. Not determined	a. ? Mt. Shasta b. Not determined c. Not determined
6. Center of dispersal of nearest ally		As indicated in the above columns		
7. Center of evolutional tendencies	Palomar-Santa Rosa Cuyamaca		Not determined	Not determined

called Ice Age, was of long duration and is thought to have been divided into several warmer inter-glacial epochs. At the beginning of the Pleistocene the flora and fauna of this region were essentially of a temperate type and included many surviving forms. At the period of maximum glaciation, however, the biota was reduced both in number and in kinds.[1] If the remains produced by the Conard Fissure are correctly placed in point of time, they would indicate that the climate of Arkansas at that time was much the same as British Columbia at present, with an analagous fauna.[2] The larch extended as far south as Georgia.[3] The climate of California at that time has been compared to the present climate of the Olympic Peninsula, cool and rainy, and productive of heavy forests.[4] To the east of the ice-covered Sierra and Cascade ranges lay a vast upland correspondingly elevated, with a higher rainfall than at present, and characterized by the great inland lakes Lahontan and Bonneville which were fed from the rivers and glaciers of the Sierra Nevada and Cascade Ranges and Wasatch Range.[5] The musk-ox ranged as far south as Salt Lake City, indicating in the north a tundra-like region.[6]

There is, then, fairly certain evidence of the repeated displacements of the existing biota during the Pleistocene and a consequent actual southward migration of both plants and animals together with the reappearance of the survivors as the climate ameliorated.

As at present constituted *Monardella* is an inhabitant either of semi-arid or arid situations in the transition zone, or of the chaparral. From a study of the apparent evolutionary tendencies it has been suggested that the genus represents a group of plants of mesophytic origin which has become more and more adapted to such a habitat. It does not seem probable that the genus maintained its present range during the Pleistocene. It is obvious that most of its present range east of the great valley of California would have been uninhabitable by reason of the boreal

[1] Osborn, H. F. The age of mammals, p. 500. 1910.

[2] Osborn, H. F. *l. c.* pp. 487–488.

[3] Osborn, H. F. *l. c.*, pp. 449.

[4] Smith, J. P. Salient events in the geologic history of California. Science N. S. **30**: 346–351. 1909.

[5] Gilbert, G. K. Lake Bonneville. U. S. Geol. Surv. Monogr. **1**: 1–438. 1890.

[6] Osborn, H. F. *l. c.* p. 485.

or sub-boreal nature of the stations. While the genus may have existed at lower levels on the great plateau, the facts of present distribution suggest rather that it has entered this area since the glacial period. Nor does it seem probable that the present range in California was maintained, in view of the fact that the genus is at present rarely found even in the outskirts of the northwestern hygrophytic forests which presumably extended much further south during the Pleistocene. One is led consequently to the conclusion that *Monardella* or its precursors migrated southward at this time. Such a conclusion is supported by other facts of present distribution.

There is evidence to suggest that, at the time of maximum elevation during the Pleistocene, the Channel Islands off the coast of southern California (? Lower California also) were continuous with the present mainland and evidently supported a similar biota. With the subsequent depression the connecting valleys were flooded and eventually only the highest points which constitute the present islands were left uncovered. The present flora of these islands,[1] while essentially that of the present mainland, nevertheless contains at least one genus no longer found upon the mainland and numerous endemic species as well, suggesting very strongly the preservation of certain types through isolation.

Monardella has been reported from these islands twice, namely, from Santa Catalina Island and from Cedros Island. *M. lanceolata* was reported from Santa Catalina Island by Lyon. The author has seen no material supporting this report nor was Millspaugh[2] able to verify it after examination of Lyon's collection. If seen by Lyon it is not improbable that the plant was a recent adventive. The only species definitely known to grow on any of these islands is *M. thymifolia* Greene, endemic on Cedros

[1] Watson, S. On the flora of Guadalupe Island, Lower California. Proc. Am. Acad. **11**: 105–121. 1876; Lyon, W. L. The flora of our southwestern archipelago. Bot. Gaz. **11**: 197–205, 330–336. 1886; Greene, E. L. Botanical excursion to the island of San Miguel. Pittonia **1**: 74–93. 1887; Botany of Cedros Island. *Ibid.* 194–208. 1888; Supplementary list of Cedros Island plants. *Ibid.* 266–269. 1889; Vegetation of San Benito Islands. *Ibid.* 261–266. 1889.

[2] Millspaugh, C. F., and Nuttall, L. W. Flora of Santa Catalina Island. Field Mus. Nat. Hist. Publ. 212. 1923.

Island. Since *M. thymifolia* is most nearly allied to *M. villosa*, yet separated from it by perhaps 750 miles, occurring as it does at the southernmost extreme of the generic range, it may be inferred that the common stock from which both have originated had a much more southerly range than *M. villosa* now occupies. Furthermore, the fact that *M. macrantha* subsp. *eumacrantha* occurs in an isolated montane community as far south as San Pedro Martir in Lower California suggests a former wider and more southerly range for that species. *M. linoides* presents a similar case.

From the inferences drawn in the preceding paragraphs we may arrive at the following explanation of the present distribution of the genus. The precursors of *Monardella* were pushed southward during the glacial period of the Pleistocene. The surviving representatives again migrated northward when conditions of climate were ameliorated. The prototypes of each of the sections previously discussed became established approximately in the present centers of dispersal of each group and were variably successful in maintaining themselves and increasing their range. With increasing aridity of the climate among other factors, and due in part to isolation, the present species have arisen, and of these the most widespread and thus, perhaps, the most successful, is *M. odoratissima*.

Monardella Benth.

Monardella Benth. Lab. Gen. & Sp. 331. 1834; in DC. Prodr. **12:** 190. 1848; Benth. & Hook. f. Gen. Pl. **2:** 1185. 1876; Gray, Proc. Am. Acad. **11:** 100. 1876; Bot. Calif. **1:** 593. 1876; Syn. Fl. N. Am., ed. 2, **2**[1]**:** 356. 1886; Briq. in Engl. & Prantl, Nat. Pflanzenf. IV. Abt. 3a, 309. 1896; Howell, Fl. Northwest Am. 549. 1901; Nelson in Coulter & Nelson, Man. Cent. Rocky Mts. 430. 1909; Jepson, Fl. West. Middle Calif., ed. 2, 363. 1911; Abrams, Muhlenbergia **8:** 26. 1912; Fl. Los Angeles, ed. 2, 317. 1917; Davidson & Moxley, Fl. South. Calif. 312. 1923.

Madronella Greene, Leaflets Bot. Obs. **1:** 168. 1906; Piper, Contr. U. S. Nat. Herb. **9:** 493. 1906; Frye & Rigg, Elem. Fl. Northwest, 195. 1914; Piper & Beattie, Fl. Southeast. Washington, 216. 1914; Fl. Northwest Coast, 309. 1915; Rydberg, Fl. Rocky Mts., ed. 2, 750. 1923.

Annual or perennial herbs, of fragrant odor, with small entire or serrate leaves, flowers borne in terminal, globose, bracteate glomerules. Calyx tubular, narrow, 10–15-nerved, 5-dentate; teeth triangular, subequal, erect; throat naked. Corolla small, usually rose-purple, sub-bilabiate, the upper lip two-lobed, the lower lip three-lobed, the lips subequal, plane, the lobes linear-oblong. Stamens four, all fertile, the anterior pair exceeding the posterior, or subequal, erect, distinct, not greatly exserted. Anthers bilocular, the locules oval, subparallel to divaricate, subconfluent above but distinct. Style shortly and unequally bifid at the summit. Ovary four-parted, the nutlets oblong-oval, smooth, brown at maturity.

The type species is *Monardella odoratissima* Benth.

Key to the Subgenera[1]

A. Limb of corolla ½–1/5 the length of the tube; calyces 10–25 mm. long .... MACRANTHAE

B. Limb of corolla ½–⅔ the length of the tube; calyces 5–10 mm. long.. PYCNANTHAE

Subgenus 1. MACRANTHAE Briq. in Engl. & Prantl, Nat. Pflanzenfam. IV. Abt. 3a, 309. 1896 (adapted from Gray, Proc. Am. Acad. **11**: 100. 1876); Abrams, Muhlenbergia **8**: 26. 1912.

Stem slender, rhizomatous, the branches decumbent or ascending; glomerules loosely flowered, usually with less than 20 flowers, bracts oblong; calyx 10–30 mm. long, slender, 13-nerved;

[1] The abbreviations used herein are as follows:

BH—Baker Herbarium of Pomona College.
CAS—California Academy of Science.
CSM—Colorado State Museum, Denver.
DH—Dudley Herbarium of Leland Stanford University.
FM—Field Museum of Natural History, Chicago.
GH—Gray Herbarium of Harvard University.
J—Herbarium of W. L. Jepson.
KH—Kew Herbarium.
MBG—Herbarium of the Missouri Botanical Garden, St. Louis.
NYS—Herbarium of the New York State Museum.
OAC—Oregon Agricultural College Herbarium, Corvallis.
RMH—Rocky Mountain Herbarium, University of Wyoming.
S—Herbarium of H. St. John.
UC—Herbarium of the University of California.
US—U. S. National Herbarium at Washington.

corolla red, yellowish or pallid, the limb $^1/_2$ to $^1/_5$ the length of the tube.[1]

§ Section I—Macranthae

Key to the Species

A. Corolla 20–45 mm. long; leaves generally pubescent........*1. M. macrantha*
B. Corolla 15–18 mm. long; leaves glabrate on both surfaces......*2. M. Palmeri*

1. **M. macrantha** Gray, Syn. Fl. N. Am. ed. 2, **2**[1]: 459 (suppl.). 1886. Hall, Univ. Calif. Publ. Bot. **1**: 110. 1902.

Perennial from slender rhizomatous stems, the branches decumbent or ascending, 10–30 cm. long, seldom branching, pubescent with short recurved trichomes, or villous, purplish; leaves subcoriaceous, variable on the same plant, the blades .5–3 cm. long, ovate to lanceolate, subcuneate at the base and generally broadest about one-quarter their length from the base, very obtuse, entire or obscurely crenate-serrate, glabrous to villous or cinereous on petioles .5–1.5 cm. long; glomerules *2–4 cm. broad*, bracts oblong-elliptical, approximately equal to the calyces, acute, membranous, purplish or whitish, sparsely villous, ciliate; calyx variable in size on the same plant, *1.2–2.5 cm. long*, purplish or green, sparsely villous, teeth acute, slender, villous within; corolla *scarlet to yellowish* or pallid, puberulent, the tube greatly exserted, the limb 5–11 mm. long, the upper lip the longer, the lobes coalesced more than half the length of the lip, those of the lower lip nearly free; the anther 1–1.5 mm. wide, the sacs widely divergent, the connective wider than the length of the sac, the margin retuse.

Key to the Subspecies

Corolla for the most part 35–45 mm. long; calyx 20–25 mm. long... subsp. *eumacrantha*
Corolla for the most part 25–30 mm. long; calyx 12–15 mm. long... subsp. *nana*

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[1] All measurements of flower parts herein given are based upon flowers which were fresh and in full bloom when pressed and which were boiled in water prior to study. It should be observed that flower parts which have withered naturally before pressing never regain their full size but remain much shrunken. If the flower to be examined be dissected upon a microscope slide mounted in a drop of thin mucilage, it may be preserved indefinitely without shrinkage by allowing the mucilage to dry. On addition of a drop of warm water it may again be examined.

a. Subsp. **eumacrantha,** nom. nov.

Monardella macrantha Gray, Proc. Am. Acad. **11:** 100. 1876; Bot. Calif. **1:** 593. 1876, **2:** 476. 1880; Syn. Fl. N. Am., ed. 2, **2**[1]: 356. 1886; Abrams, Muhlenbergia **8:** 28. 1912; Davidson and Moxley, Fl. South. Calif. 313. 1923.

Madronella macrantha Greene, Leaflets Bot. Obs. **1:** 169. 1906.

Blades of the leaves *1–3 cm. long,* glabrate above and pubescent beneath, rarely pubescent on both surfaces (villous in the variety); glomerules 3–4 cm. broad, *bracts seldom equaling the calyces, purple;* calyx in general *20–25 mm. long;* corolla scarlet or yellowish, in general 30–45 mm. long, the anthers 1.25–1.5 mm. wide.

Specimens examined:

California: Big Sur, May–June, 1901, *Davy 7436* (UC); Santa Lucia Mts., June 10, 1909, *Brandegee* (UC); Cuyamaca Mts., July 12, 1875, *E. Palmer 295* (GH, type; MBG); Cuyamaca Mts., Sept. 1882, *Orcutt 485* (GH); San Diego Co., *Orcutt* (MBG); Santa Lucia Mts., 1885, *Brandegee* (GH); Tassajara Hot Springs, Monterey Co., June 1901, *Elmer 3228* (MBG; US); Laguna Mts., June 28, 1919, *Eastwood 9227* (GH); Smith Mt., San Diego Co., July 25, 1882, *Orcutt* (MBG); between Cuyamaca and Julian, June 21, 1903, *Abrams 3812* (US; MBG; GH) Julian City July 15, 1875, *Cleveland* (GH); Cuyamaca Peak, 5000 ft., June 30, 1897, *Reed* (BH); Cuyamaca Lake, dry stony slopes, 4700 ft., June 27, 1923, *Munz & Harwood 7241* (BH); Laguna Mts., July, 1889, *Orcutt* (US); Santa Lucia Mts., 1880, *G. R. Vasey 487* (US); Cuyamaca Mts., 1875, *E. Palmer 294* (US); Julian, Cleveland Nat. Forest, July 29–30, 1915, *Hitchcock* (US); Pine Hills, July 29, 1915, *Collins & Kempton 268* (US); West Fork Trail near Sturdevant's, San Gabriel Mts., 4250 ft., July 13, 1918, *Peirson 183* (J).

Lower California: San Pedro Martir, Aug. 1903, *Robertson 33* (UC, leaves small for the plant and pubescent on both sides); Oallecitos, San Pedro Martir, 8000 ft., July 15, 1905, *Goldman 1228* (US).

Var. **Hallii** Abrams, Muhlenbergia **8:** 29. 1912; Davidson and Moxley, Fl. South. Calif. 313. 1923.

M. macrantha var. *tenuiflora* Hall, Univ. Calif. Publ. Bot. **1:** 110. *pl. 11.* 1902 (neither of Watson nor Gray).

M. macrantha var. *longiloba* Abrams, Muhlenbergia **8**: 29. 1912; Davidson and Moxley, Fl. South. Calif. 313. 1923.

Branches and leaves villous, the latter in general 2 cm. long or more and tending to be ovate rather than lanceolate, frequently subtruncate at the base and very obtuse; corolla frequently yellowish, *the limb being sometimes as long as 10–11 mm., the lobes being correspondingly slender and very acute.*

Specimens examined:

California: Smith Mt., San Diego Co., July 19, 1890, *I. J. Gray* (MBG); chaparral belt of south side, canyon of the San Jacinto R., 4300 ft., July 4, 1898, *Hall 976* (UC, type of var. *longiloba* Abrams; US; fragment GH); San Jacinto Mts., 4000 ft., July 16, 1897, *Hall 687* (UC); chaparral belt, San Jacinto River, 4400 ft., June 19, 1897, *Hall 669* (UC); Mill Creek, San Bernardino Co., July 8, 1898, *Parish 4578* (US); San Bernardino Co., 1876, *Parry & Lemmon 328* (GH; MBG); Palomar, May, 1901, *Hall 1936* (MBG; US; *type collection*, type in Dudley Herb.); City Creek Road, San Bernardino Mts., 5000 ft., July 17, 1921, *Johnston 2858* (BH).

b. Subsp. **nana** (Gray), comb. nov.

Monardella nana Gray, Proc. Am. Acad. **11**: 101. 1876; Bot. Calif. **1**: 593. 1876; Syn. Fl. N. Am., ed. 2, 2^1: 356. 1886; Abrams, Muhlenbergia **8**: 30. 1912; Davidson & Moxley, Fl. South. Calif. 313. 1923.

M. macrantha var. *nana* Gray, Syn. Fl. N. Am. ed. 2, 2^1: 459 (suppl.). 1886; Hall, Univ. Calif. Publ. Bot. **1**: 111. 1902.

M. villosa var. *leptosiphon* Torrey, Bot. Mex. Bound. 129. 1859 (*not* Gray, Bot. Calif. **1**: 593. 1876; Syn. Fl. N. Am., ed. 2, 2^1: 357. 1886).

M. nana var. *leptosiphon* Abrams, Muhlenbergia **8**: 31. 1912; Davidson and Moxley, Fl. South. Calif. 313. 1923.

Madronella nana Greene, Leaflets Bot. Obs. **1**: 169. 1906.

Blades of the leaves in general *.5–1.5 cm. long*, less commonly 2 cm. long, ovate rather than lanceolate with a tendency to become truncate at the base, glabrous on the upper surface and pubescent beneath or sparsely villous or cinereous throughout; glomerules 2–3.5 cm. broad, *bracts usually somewhat longer than*

the calyces and often whitish; calyx in general *12–16 mm. long,* corolla pinkish or pallid, in general 20–35 mm. long, the anthers 1 mm. wide.

Specimens examined:

California: Cuyamaca Mts., 4500 ft., May 29, 1899, *Hall 1202* (UC); mountains in back of San Diego, 1875, *Cleveland* (GH; type); San Felipe, 1881, *Cleveland 770* (GH); between Cuyamaca and Oriflamme Canyon, San Diego Co., June 28, 1903, *Abrams 3941* (GH; MBG; BH; US); Laguna Mts., San Diego Co., June 28, 1919, *Eastwood 9215* (US; GH); Laguna Mts., San Diego Co., July, 1889, *Orcutt* (MBG; US); Laguna Mts., 5700 ft., June 2, 1920, *Spencer 1560* (BH); Laguna, June 14, 1894, *Schoenefeld 3544* (US); Julian, 1880, *Vasey* (US); Smith Mt., San Diego Co., July, 1882, *Orcutt* (GH); Julian, San Diego Co., June 13, 1894, *Brandegee* (UC); Smith Mt., July 15, 1890, *Orcutt 2110* (US).

Lower California: mountains of Lower California (near Japa), July 5, 1884, *Orcutt* (FM).

Var. **tenuiflora** Gray, Syn. Fl. N. Am., ed. 2, 2[1]: 459. 1886 (suppl.); not of Hall, Univ. Calif. Publ. Bot. **1:** 110. *pl. 12.* 1902.

Monardella tenuiflora Watson in Gray, Proc. Am. Acad. **17:** 230. 1882.

M. nana var. *tenuiflora* Abrams, Muhlenbergia **8:** 32. 1912; Davidson & Moxley, Fl. South. Calif. 313. 1923.

M. macrantha var. *pinetorum* Hall, Univ. Calif. Publ. Bot. **1:** 110. *pl. 12.* 1902.

Branches 10–15 mm. tall, *short-pubescent;* leaves *cinereous-pubescent,* the trichomes usually appressed but frequently somewhat villous, blades averaging 1 cm., the petioles 4–5 mm.; corolla pale yellow to almost white; the *tube averaging 20 mm.,* barely tapering, the limb *6–8 mm.* long, the *lobes acute, narrower at the base than towards the middle,* somewhat exceeding the stamens.

Specimens examined:

California: Santa Rosa Mts., frequent in partly shady rocky slopes in the chaparral belt, 5700 ft., June 26, 1922, *Munz 5833* (BH); between Tahquitz and Round Valley, San Jacinto Mts., 7500 ft., July 6, 1922, *Munz 6033* (BH); San Jacinto Mts., 6000–

8000 ft., July 17, 1897, *Hall 691* (UC; fragment in GH); San Jacinto Mts., Aug. 1881, *S. B. & W. F. Parish 327* (UC); San Jacinto Mts., July, 1880, *S. B. & W. F. Parish 327* (GH, TYPE; MBG; US); San Jacinto Mts., 8500 ft., July 2, 1895, *A. W. Anthony* (UC); Fuller's Mills Mts., San Jacinto Range, 6500 ft., July, 1901, *Hall 2559* (UC, this and the following approach subsp. *eumacrantha* var. *Hallii* in the structure of the corolla but retain the small anther; in size of corolla they are very similar to Elmer's collection of *M. macrantha* at Tassajara); pine-clad slopes of west side (San Jacinto Canyon), 6000 ft., June 24, 1901, *Hall 2258* (UC); Tahquitz Valley, San Jacinto Mts., July 22, 1897, *Hall 725* (UC, 25479, TYPE of *M. macrantha* var. *pinetorum* Hall; US); San Jacinto Mt., halfway between forks of Summit Trail and Log Cabin on upper trail, 8000 ft., no date, *Jepson 2322* (J); Palm Canyon and return to Van Deventer's, May 17–June 1, 1901, *Jepson & Hall 1336* (J).

LOWER CALIFORNIA: Japa, 9000 ft., July 5, 1884, *Orcutt* (GH).

Var. **arida** Hall, Univ. Calif. Publ. Bot. **1**: 111, *pl. 10*. 1902.
M. nana var. *arida* Abrams, Muhlenbergia **8**: 33. 1912; Davidson & Moxley, Fl. South. Calif. 313. 1923.

Low, branches less than 10 cm. long, *cinereous; leaves cinereous*, the blades 0.5–1.0 cm. long, the petioles often longer, averaging about three-fourths the length of the blade; corolla pale yellow to almost white; the *tube less than 18 mm.* long, scarcely tapering, *less than a millimeter wide*, the limb *4–6 mm.* long, *the lobes oblong* rather than tapering, often obtuse, exceeding the stamens slightly.

Specimens examined:

CALIFORNIA: desert region to the southeast of San Jacinto Mt., along Coyote Creek at 5000 ft., June, 1901, *Hall 2127* (UC 25475; MBG; US); Coyote Canyon, Santa Rosa Mt., 5000 ft., May, 1899, *Hall 1180* (UC; RMH; US); between Vandeventer's and Palm Canyon, San Jacinto Mts., 4000 ft., May, 1901, *Hall 1852* (UC); Old Nicholas Canyon, Santa Rosa Mts., common in dry clearings in chaparral, 5000 ft., July 1, 1922, *Munz 5936* (BH).

M. macrantha was based originally upon the collections of both Cleveland and Palmer, the first collected at "Julian City," the second in the "Cuyamaca Mts." In a note at the end of the

original description Gray interchanged the order of the collectors' names and the localities from whence the collections were made and wrote "Southern part of California in the Cuyamaca Mountains and near Julian City, D. Cleveland, E. Palmer." Both collections at the Gray Herbarium are mounted upon the same sheet and are similar although the former is scant. It is evident that the original description is drawn mainly from the Palmer collection and since, of the two, it only is labeled in Gray's hand "*Monardella macrantha* n. sp." and is more copiously represented, it is here considered the historical type.

In the same paper in which *M. macrantha* was published, *M. nana* was described and united with it to form a generic section. *M. nana* was based upon a collection by Cleveland in the same year and same locality. The two species thus constituted were published again in the 'Botany of California' and in the 'Synoptical Flora.' In the supplement to the second edition of the latter, however, *M. nana* was made a variety of *M. macrantha*, together with *M. tenuiflora* Wats. published in 1882. This interpretation was accepted by Hall, who studied the plants in the field and described two varieties as new, referring certain plants to *M. macrantha* var. *tenuiflora* (Wats.) Gray. One of the newly described varieties was *M. macrantha* var. *pinetorum*. A comparison of the plants referred to var. *tenuiflora* with the type specimen indicated to Abrams that this variety had been misinterpreted by Hall and that *M. macrantha* var. *pinetorum* Hall was in fact *M. macrantha* var. *tenuiflora* Gray. Abrams therefore applied the name *M. macrantha* var. *longiloba* to the plants referred by Hall to *M. macrantha* var. *tenuiflora*, and named the plants referred by Hall to *M. macrantha* (not the variety) var. *Hallii*, since they did differ from the type of *M. macrantha* in the villosity of the foliage.

The chief character upon which var. *longiloba* was based lay in the unusually long (10 mm. or more) lobes of the corolla which were correspondingly slender and acute. The chief character upon which var. *Hallii* was based lay in the abundant villosity of the foliage. The present author agrees with Abrams that *M. macrantha* var. *tenuiflora* Hall is not synonymous with *M. macrantha* var. *tenuiflora* Gray. A careful study of the group,

however, has not demonstrated that var. *longiloba* and var. *Hallii* may be segregated by any constant group of characters.

M. macrantha varies tremendously, and yet, as stated by Hall, all gradations between the extremes may be found nor do any very constant lines of cleavage appear to exist. The combinations of characters which appear are very puzzling. The clearest hiatus appears between those groups herein described as subspecies. Subsp. *eumacrantha,* on the one hand, is made up of plants which are more or less lax in their habit, trailing, with leaves which are comparatively large, being 2–3 cm. long, and with flowers unusually large for the genus, being in general 30–45 mm. long and scarlet or yellowish. Subsp. *nana,* on the other hand, has a more compact growth form, particularly in the plants of more arid habitat, with smaller leaves and flowers which are pinkish or yellowish-white and in size from 20 to 35 mm. long. The pubescence of this group is more often dense and close, giving a cinereous aspect to the plant.

In the first subspecies, while the range of variation is considerable, there does not seem to be any very definite occurrence of concomitant characters save that, in general, plants with the larger ovate villous leaves also have the elongated lobes of the corolla. Such plants have accordingly been referred to var. *Hallii,* and since the occurrence of the elongate lobes is more or less connected with the villous leaves, var. *longiloba* is considered synonymous with it. All gradations exist.

In the second subspecies two variants from the more typical plant may be more clearly discerned and appear to have a distribution which is characteristic. The subspecies proper has foliage which in general resembles that of subsp. *eumacrantha* and like it varies from pubescent to villous, but is in general smaller, ranging from 1 to 2 cm. in length. The pubescence, however, is closer and more cinereous. The corolla is smaller, and presents one or two qualitative differences as well, namely, in the shape of the tube, which is evenly tubular and less funnel-form, and in the shape of the lobes, which are more slender and usually slightly narrower at the base and longer in proportion to the length of the tube. The anthers are distinctly smaller, averaging 1 mm. in width. These differences were noted by Abrams and used as

a means to segregate *M. nana*. Nevertheless, they are not constant, the form described by Torrey as *M. villosa* var. *leptosiphon* clearly connecting the two subspecies.

The variety *tenuiflora* (var. *pinetorum* Hall) has smaller leaves (1 cm.), which are distinctly cinereous on both surfaces with a corolla much exserted, the limb being 6–8 mm. long, the lobes very acute. The petioles of the leaves are somewhat less than half the length of the blade. The variety *arida* has similar foliage but smaller, the blades being .5–1 cm. long and the petioles often three-fourths the length of the blade. The growth form is very compact. The corolla is much less exserted, the limb being 4–6 mm. long, the lobes oblong-linear and rather blunt. All gradations occur.

It is impossible from present knowledge of the group to judge to what extent these forms represent racial differences and to what extent they represent forms induced by the environment. To determine this will require careful field study and experiment.

The present author has not seen the type of *M. villosa* var. *leptosiphon* which was based upon a collection by Parry at "San Felipe," but from the description there can be little doubt as to the plant referred to, particularly so from the description of the corolla and stamens. It was confused by Gray with a subspecies of *M. villosa* common to central California, an error which was perpetuated until attention was directed to it by Abrams, and in the Gray Herbarium there is apparently no authentic material of Torrey's plant.

2. **M. Palmeri** Gray, Proc. Amer. Acad. **12:** 82. 1877; Bot. Calif. **2:** 476. 1880; Syn. Fl. N. Am., ed. 2, **2**[1]: 357. 1886.

Madronella Palmeri Greene, Leaflets Bot. Obs. **1:** 169. 1906.

Perennial from a slender, rhizomatous stem, the branches low, ascending, 10–15 cm. long, purplish, *scarcely puberulent;* leaves subcoriaceous, 1–2 cm. long, *oblong or lanceolate-oblong,* entire or nearly so, obtuse, glabrous, the midvein hardly perceptible, tapering into a very short petiole or sessile; glomerules large in proportion, 2.5–3 cm. broad, purplish, bracts exceeding the calyces, oblong, the innermost linear-oblong, obtuse, thin and membranous, reddish purple, puberulent; calyx 9–11 mm. long, red-

dish purple, 13-veined, rather definitely bilabiate, the teeth slender, 1.5–2 mm. long, hirsute within; corolla 15–17 mm. long, the tube slender, twice the length of the limb, retrorsely hirsute in the throat, the limb 5–6 mm. long, the lips about equal, the lobes of the upper lips coalesced about one-half its length, those of the lower lip approximately free, tapering slightly; stamens about equal, the anthers less than 1 mm. wide, the anther-sacs divaricate, the angle about 90°, the margin of the connective apparently entire, or if retuse, very slightly; nutlets 2.5 mm. long.

Specimens examined:

CALIFORNIA: Santa Lucia Mts., under the redwoods, Aug. 2, 1876, *E. Palmer 359* (GH, TYPE; MBG; US); no locality given, *Brandegee* (GH); Santa Lucia Mts., July, 1880, *Vasey 498* (US; FM).

Subgenus 2. PYCNANTHAE Briq. in Engler & Prantl, Nat. Pflanzenf. IV. Abt. 3a, 309. 1906 (adapted from Gray, Proc. Am. Acad. **11**: 101. 1876); Abrams, Muhlenbergia **8**: 26. 1912.

Stems various, decumbent or erect but not rhizomatous; glomerules compactly flowered, usually with thirty or more flowers; bracts variable, tending to ovate or lanceolate; calyx 5–10 mm. long, 10–15-nerved; corolla rose-purple or pallid, the limb one-half to two-thirds the length of the tube.

KEY TO THE SPECIES

A. Annuals; stem herbaceous and not suffrutescent.
- a. Bracts fenestrate, i.e., the intravenous tissue like isinglass .... *13. M. Douglasii*
- b. Bracts membranous or scarious, but not fenestrate.
  - α Margin of the calyx teeth white-scarious or terminating in a white, recurved cusp.
    - 1. Teeth ending in a white recurved cusp. ... *19. M. leucocephala*
    - 2. Teeth blunt, margin white-scarious.
      - I. Lower margin of connective entire; calyx 15-nerved. .... *18. M. exilis*
      - II. Lower margin of connective distinctly notched; calyx 13-nerved ..... *17. M. candicans*
  - β. Margin of the calyx teeth bounded by a distinct vein, not scarious.
    - 1. Leaves plane, lanceolate or oblong.
      - I. Bracts puberulent.
        - *Bracts acuminate, secondary veins absent or not prominent .... *15. M. Breweri*

**Bracts acute, secondary veins green, net-like, prominent. . . . . *14.* *M. lanceolata*
II. Bracts villous throughout. . . . . *16.* *M. Pringlei*
2. Leaves undulate or crisped, oblanceolate-oblong. . . . . *12.* *M. undulata*

B. Perennials; stem woody at the base and suffrutescent.
a. Leaves oblanceolate-oblong, undulate or crisped. *12.* *M. undulata*
b. Leaves ovate to linear, plane.
α. Bracts reflexed, foliar in texture and shape. *4.* *M. villosa*
β. Bracts erect, sheathing, firm or membranous, but only the outer pair foliar (see also *M. villosa* subsp. *neglecta*).
1. Leaves with a strongly developed felt-like tomentum on the under surface, glabrous or lanate above.
I. Leaves glabrous above.. . . . . *5.* *M. hypoleuca*
II. Leaves lanate above . . . . *6.* *M. lanata*
2. Leaves pubescent or glabrous, often paler beneath, but never felt-like.
I. Leaves .5–.8 mm. long, more or less crenate-dentate.
*Plant short pubescent, cinereous, not villous. . . . . *3.* *M. thymifolia*
**Plant short-villous, hoary with a bluish cast. *9.* *M. cinerea*
II. Leaves 1–several cm. long, mostly entire.
*Foliage and stem silvery white, with a dense microscopic puberulence; leaves typically linear-oblong. . . . . *11.* *M. linoides*
**Foliage and stem glaucous-like in some but not silvery white; leaves typically lanceolate.
†Bracts firm, neither membranous nor chaffy; lobes of corolla blunt.
‡Leaves glabrous above, 2–5 mm. long. . . . . *8.* *M. saxicola*
‡‡Leaves pubescent on both surfaces, seldom 2 cm. long . . . . *7.* *M. viridis*
††Bracts membranous, often reddish-purple; lobes of corolla rounded to a point. . . . . *10.* *M. odoratissima*

§ Section II. Villosae

3. M. thymifolia Greene, Bull. Calif. Acad. Sci. **1:** 211. 1886; Gray, Syn. Fl. N. Am., ed. 2, **2**[1]**:** 459. 1886.

Madronella thymifolia Greene, Leaflets Bot. Obs. **1:** 169. 1906.

Perennial, shrubby, 12–20 cm. tall, *much branched, the lower branches woody,* covered with a grayish brown checking bark, spreading, the upper branches erect, slender, pubescent; leaves 5–8 mm. long, ovate triangular, very obtuse, margin recurved, entire or obscurely serrate, soft-pubescent, petioles broad, 1–2 mm. long; *glomerules a centimeter or less in diameter,* bracts ovate, acute, equaling the calyces, herbaceous (Greene), *becoming chaffy and brittle,* pinnately veined, thinly pubescent, the margin subciliate; calyx 6–7 mm. long, thinly pubescent; corolla purplish (Greene), 12–13 mm. long, the tube about 8 mm. long, the lips subequal; the lobes of the upper lip coalesced about two-thirds its length, those of the lower lip about one-fourth its length, tapering but little, obtuse, anther-sacs divergent, the connective equilateral, well developed, nutlets oblong-oval, 1.5 mm. long.

Specimens examined:

Lower California: Cedros Island, 1859, *Veatch* (UC; GH); Cedros Island, July–Oct. 1896, *A. W. Anthony 143* (US; GH); Cedros Island, March–June, 1897, *Anthony 316* (GH; MBG; US); Cedros Island, March 22, 1911, *Rose 16162* (US).

The few specimens which are available for study are uniform in appearance, but are for the most part past flower, the glomerules being dry and chaffy and straw-colored. The bracts are stated by Greene to be herbaceous. The only specimen examined in which this point might be determined (US 313872) showed the outer pair erect and subfoliaceous only, the inner being membranous but firm, the veins being well developed. All were tinged with rose and were noticeably pubescent and glandular.

4. M. villosa Benth. Bot. Voy. Sulph. 42. *pl. 21.* 1844; in DC. Prodr. **12:** 190. 1848; Gray, Proc. Am. Acad. **11:** 101. 1876; Bot. Calif. **1:** 593. 1876, excl. variety; Syn. Fl. N. Am., ed. 2, **2**[1]**:** 357. 1886, excl. variety; Jepson, Fl. West. Middle Calif., ed. 2, 364. 1911.

Perennial from decumbent stems, woody at the base, the bark

brown in old stems, often checking; the branches erect, simple, or often with short, usually sterile secondary branchlets; of variable stature, 10–60 cm. tall, variably pubescent near the inflorescence, glabrate below; leaves exceedingly variable, *in general ovate*, varying, on one hand, to rotund and, on the other, to lanceolate, obtuse, *obscurely crenate-serrate*, or entire, or coarsely dentate-serrate, usually of a firm texture, *villous or villous-tomentose* to glabrate, blades 1–3 cm. long, rounded at the base, but abruptly tapering into a petiole 0.5–1.0 cm. long; glomerules compact, 2–4 cm. broad, *bracts leaf-like in shape and texture*, only the innermost sometimes membranous, about equal to the calyces, *reflexed*, villous or tomentose, conforming to the pubescence of the plant; calyx 7–10 mm. long, 13-nerved, scarious below, green and *shaggy-villous above*, teeth ovate-triangular, villous without and on the margins; corolla 10–18 mm. long, rose-purple to pallid, the *lobes linear-oblong and ribbon-like*, blunt, those of the upper lip coalesced usually about half its length, those of the lower lip nearly or wholly free; stamens about the length of the lobes, the filaments retrorsely hispidulous near the base, the anther sacs divergent, the connective equilateral, well developed.

The following classification represents an attempt to characterize what appear to be the principal tendencies of evolution within *M. villosa*. In each subdivision of its range may be found a form which is characteristic of that locality, and while forms geographically distant may be quite diverse all intermediate forms may be found and, taken as a whole, show a close correlation between form and geographical position. This is true to the extent that, after familiarity with the species and its distribution as a whole has been attained, it is possible to place any given plant within a comparatively short distance of its habitat merely by inspection. There are not hard-and-fast lines between these areas of distribution just as there may not be found any constant morphological differences between the forms that inhabit them. Yet taken in their typical aspect, as represented by the modal points in the curve of their variability, it will be found that each subspecies occupies a fairly distinct territory, certainly of a degree of distinctness to be very suggestive. The subsp. *euvillosa*, characterized by leaves which are rather large,

thinnish, ovate, sharply serrate and villous, is found along the coast from the Santa Lucia range northward to Mendocino County, the variety *fransiscana* being evidently a form of the littoral. The next and most nearly allied subspecies with which it intergrades imperceptibly is subsp. *subserrata*. This subspecies is characterized by a usually smaller lanceolate leaf which is typically lanceolate and is shallowly serrate. The pubescence is villous but much finer, being frequently subtomentose. Subsp. *subserrata* is found in the Salinas Valley and ranges northward through the coastal valleys to the Bay region and Napa County and northward to Mendocino County. It occurs occasionally in the Sierra Nevada, and in southern Oregon but at low elevations.

Subsp. *Sheltoni*, characterized by a lanceolate, even narrower leaf, which is nearly or quite entire and is glabrate, or puberulent at most, is found chiefly in the Sierra Nevada at elevations as high as 7300 feet and in the Siskiyou Mountains of northern California and southern Oregon. Transitional forms occur on the valley side of the coast range in Central California.

Subsp. *neglecta* is a very doubtful form which is herein treated as a subspecies for convenience and for the purpose of directing attention toward it. It occurs only in the vicinity of Mt. Tamalpais.

Key to the Subspecies

A. Herbage variously pubescent.
 1. Leaves ovate to roundish, villous and green rather than canescent or cinereous....................subsp. *euvillosa*
 2. Leaves lanceolate, rarely ovate, canescent or cinereous....................subsp. *subserrata*

B. Herbage puberulent at most.
 1. Bracts leaf-like, not markedly ciliate............subsp. *Sheltoni*
 2. Bracts membranous, purple, ciliate...............subsp. *neglecta*

a. Subsp. **euvillosa**, nom. nov.

Monardella globosa Greene, Pittonia 5: 32. 1902.

M. involucrata Heller, Muhlenbergia 1: 35. 1904.

Madronella villosa Greene, Leaflets Bot. Obs. 1: 168. 1906.

Madronella globosa Greene, Leaflets Bot. Obs. 1: 169. 1906.

Madronella involucrata Heller, Muhlenbergia 1: 136. 1906.

Branches villous in the upper nodes, leaves ovate, commonly serrate, the teeth of variable prominence, 1–3 cm. long, for the most part 2–2.5 cm., tending to become truncate at the base, rather than cuneate; corolla 12–15 mm. long, the lobes of the upper lip somewhat less than half its length, those of the lower lip somewhat less than its full length.

Specimens examined:

California: Berkeley, July 4, 1880, *Engelmann* (MBG); Woodside, San Mateo Co., June 9, 1919, *Wattlier* (GH; US); mountains near Santa Cruz in shaded woods, 186–, *Bolander* (GH); "Potrero, near San Francisco, July 30, 1868," *Kellogg & Harford 775* (GH; MBG); Goat Island (San Francisco Bay), June 8, 1882, *Greene* (FM); foothills west of Los Gatos, June 11, 1904, *Heller 7497* (RMH; MBG; OAC; GH; US; foliage varies exceedingly on different sheets of this collection); San Mateo Co., Aug. 11–12, 1897, *Congdon* (GH); Santa Cruz, June 16, 1903, *Thompson* (MBG); no locality, *Coulter 541* (GH; cited by Bentham); Pine Forest at Pacific Grove, Aug. 16, 1905, *Coleman* (DH); Madrone Springs canyon (? Sonoma Co.), 2000 ft., Aug. 14, 1917, *Abrams* (DH); California Redwood Park, Santa Cruz Co., June 18, 1919, *Shockley* (DH); Crystal Springs, June 30, 1903, *Baker 3353* (GH; MBG); Bay-View Hills, June 13, 1912, *Eastwood 349* (US; GH; MBG); Saratoga, Big Basin Road, June 23, 1915, *Abrams 5273* (DH); Angel Island near San Francisco, *Vasey* (GH); Borax Lake, 1865, *Torrey 403a* (GH); New Almaden, 1865, *Torrey* (GH); Mare Island, June 9, 1874, *Greene 226* (GH); Contra Costa, July, 1903, *Elmer 4658* (MBG; US); Niles, Morrison Canyon, June 20, 1897, *Jepson 59h* (J); Weldon Canyon, Vaca Mts., Solano Co., June 1, 1891, *Jepson 50l* (J); Glen Echo, Santa Cruz Co., June 17, 1896, *Jepson 59g* (J); Ft. Bragg, 1914, *Mathews 169* (J; typical); no locality, *Hartweg 1913* (GH); Monterey, *Haenke* (GH); near San Francisco, 1866, *Kellogg* (US). sandy loam, Pajaro Hills, Monterey Co., June-July, 1899, *Chandler 366* (US); San Leandro, Contra Costa Co., June 21, 1915, *Eastwood 4743* (US); Santa Cruz Mts., July 9, 1913, *Hitchcock 221* (US); N. Berkeley Hills, June 30, 1917, *Walker 605* (US); Santa Clara Co., June 1, 1895, *Dudley 4200* (US); Santa Cruz Mts., July 22, 1882, *Pringle* (US).

Var. **franciscana** (Elmer), comb. nov.

Monardella franciscana Elmer, Bot. Gaz. **41:** 320. 1906.

Madronella franciscana Heller, Muhlenbergia **2:** 244. 1906.

Branches villous to *tomentose* in the upper parts; leaves ovate to *rotund, thickish*, obscurely serrate to entire, truncate at the base, even subcordate, the blades commonly about 2 cm. long, villous above, *tomentose and canescent beneath;* corolla 12–18 mm. long, the lobes tapering somewhat, appearing as though foreshortened, those of the upper lip one-third to one-half its length, those of the lower lip somewhat less than its length, the throat more ample than in subsp. *euvillosa.*

Specimens examined:

California: Santa Lucia Mts., 1885, *T. S. Brandegee* (GH); San Juan, back of Monterey, June 14, 1861, *Brewer 713* (GH; US); no locality given, 1853, *Gibbons* (GH); Pine Mt., near San Simeon Bay, San Luis Obispo Co., July 22, 1876, *E. Palmer 361* (US; MBG); San Mateo, July, 1903, *Elmer 4766* (MBG; UC; US; *type collection* of *M. franciscana* Elmer, type in DH); Santa Lucia Mts., Monterey Co., June, 1898, *Plaskett* (GH; US); San Bruno Hills, near Ocean View, San Francisco Co., June 8, 1906, *Heller 8371* (MBG; GH; US); no locality given, 1876, *E. Palmer 360* (US; suggests *M. hypoleuca*).

b. Subsp. **subserrata** (Greene), comb. nov.

Monardella subserrata Greene, Pittonia **5:** 81. 1902.

M. tomentosa Eastwood, Bull. Torr. Bot. Club **30:** 496. 1903.

M. villosa Howell, Fl. Northwest Am. 549. 1901.

M. villosa var. *leptosiphon* Gray, Syn. Fl. N. Am., ed. 2, **2**[1]: 357. 1886 (not Torrey).

M. mollis Heller, Muhlenbergia **1:** 35. 1904.

Madronella mollis Heller, Muhlenbergia **1:** 138. 1906.

Madronella gigantea Heller, in herb. (Heller 12395). 1916.

Madronella subserrata Greene, Leaflets Bot. Obs. **1:** 169. 1906.

Stems *villous or at least pubescent* in the upper nodes; leaves *lanceolate*, rarely ovate, commonly 2–2.5 cm. long, entire or shallowly serrate, those in the upper nodes canescent from a *villous-like tomentum, varying to a short pubescence, more dense on the lower surface, the trichomes soft and fine;* corolla 15–18 mm. long, the lobes ribbon-like, scarcely tapering, blunt, those of the upper

lip one-half its length or more, those of the lower lip usually equal to it.

Specimens examined:

CALIFORNIA: Arroyo del Puerto, Stanislaus Co., June 11, 1862, *Brewer 1253* (GH; US); Laytonville, Aug. 2, 1902, *Eastwood* (CAS; TYPE of *M. tomentosa* Eastwood); dry hills, Carmel R., Monterey Co., June 22, 1921, *S. B. Parish 20043* (GH); near Ladoga, Lake Co., June 8, 1919, *Heller 13241* (MBG; GH; US); Jolon, Monterey Co., Sept. 22, 1894, *Eastwood* (GH; an unusual form); Tuolumne City, 2800 ft., July 19, 1911, *Abrams 4719* (DH; approaches the preceding in the degree of pubescence); Ione, 200–500 ft., June, 1904, *Braunton 1046* (MBG; US); gravelly stream bank west of Proberta, Tehama Co., June 19, 1916, *Heller 12395* (OAC; MBG; GH; US; *type collection* of *M. gigantea* Heller); Sonoma Co., *Samuels 162* (US); Mt. Diablo, near Lake, Contra Costa Co., June 30, 1916, *Abrams 5707* (DH); road between Petrified Forest and Mark West, Sonoma Co., July 4, 1916, *Abrams 5790* (DH); between Knight's Valley and Mark West Springs, June 28, 1902, *Heller 5791* (MBG; GH; US); 3 mi. west of Leesville, Colusa Co., June 6, 1916, *Heller 12355* (GH; US; OAC; MBG); near Arnold's on Outlet Creek, Mendocino Co., July 9, 1916, *Abrams 5925* (DH); Jolon, Monterey Co., 1880, *Vasey 492* (US); Valley of Arroyo Seco, Monterey Co., May 30, 1861, *Brewer 678* (GH; US); Searsville Ridge, Santz Cruz Mts., June 2, 1914, *Abrams 1700* (US); New Idria, San Benito Co., July 24, 1861, *Brewer 798* (US); Ukiah, Mendocino Co., June 20–July 3, 1898, *Chesnut 377* (US); Round Valley (east of Mt. Diablo?), July 25, Aug. 3, 1897, *Chesnut 542* (US); mountains of the upper Sacramento, 1845–7, Fremont's 3rd Expedition (US, 43119; MBG, 114315; GH); Grass Valley, Amador Co., July 10, 1894, *Hansen 439* (US); Big Horse Mt., S. Fork Eel R., July–Aug., 1892, *Jepson 30p* (J); grade to Howell Mt., Napa R. basin, June 26, 1893, *Jepson 50 m* (J); Calistoga, June 3, 1923, *Jepson 9969* (J; *M. villosa* var. *tomentosa* Jepson); Hemlock, July 17, 1897, *Jepson* (J.).

OREGON: Roseburg, Oct. 2, 1881, *Pringle* (MBG); Grant's Pass, July 24, 1915, *Canby 103* (OAC); 4 mi. north of Agnes, June 25, 1917, *Nelson 1502* (GH); by the river, Grant's Pass, July 2, 1887, *T. Howell*, in part (US, 43117).

M. subserrata Greene is based upon a specimen collected by G. W. Dunn in Sonoma County, June, 1890. Only a photograph of this plant has been seen by the author.

c. Subsp. **Sheltoni** (Torrey), comb. nov.

Monardella Sheltoni Torrey in Durand, Pl. Pratten., Jour. Acad. Nat. Sci. Phila. II. **3**: 99. 1855.

M. villosa var. *glabella* Gray in Bot. Calif. **1**: 593. 1876; Syn. Fl. N. Am., ed. 2, $\mathbf{2}^1$: 357. 1886 (in part).

M. reflexa Howell, Fl. Northwest Am. 549. 1901.

M. dentata Rydb. Bull. Torr. Bot. Club **31**: 641. 1904.

M. coriacea Heller, Muhlenbergia **1**: 35. 1904.

Madronella coriacea Heller, Muhlenbergia **1**: 138. 1906.

Madronella dentata Rydb. Bull. Torr. Bot. Club **33**: 150. 1906.

Madronella amabilis Heller, in herb. (12567). 1916.

Stems *puberulent or glabrous* in the upper nodes; leaves ovate, tending to *lanceolate*, puberulent or *nearly glabrous*, blades commonly 2–2.5 cm. long, subcuneate at the base, *entire* or obscurely serrate, tapering into a petiole 2–5 mm. long; bracts lanceolate, reflexed, short-pubescent; corolla 12–20 mm. long, purple to whitish, the lobes of the upper lip about half its length, those of the lower its full length.

Specimens examined:

California: Klamath R., Humboldt Co., 1500 ft., June, 1901, *Chandler 1522* (GH; MBG; US); Castella, Shasta Co., July 24, 1912, *Eastwood 1369* (GH; US); Nevada Co., June 20–22, 1912, *Eastwood 581* (GH; MBG; US; type locality); Sierras, 1872, *A. Gray* (GH); no locality stated, *Bridges 307* (US; GH); no data other than this: "M. Sheltoni Torr. in herb.," in Dr. Gray's hand; the author's conception of *M. Sheltini* is based upon this plant together with the description and other plants from the type locality; Indian Valley, Plumas Co., Aug., 1896, *Austin* (MBG); Summit, between Mad and Trinity Rivers, on Eureka Red Bluff Road, July 22, 1916, *Abrams 6181* (DH); between the McCloud and Sacramento Rivers, Shasta Co., June 24, 1916, *Heller 12447* (MBG; GH; US; OAC; distributed as a form of *M. gigantea* Heller; varies considerably within the collection); Shasta River hills near Klamath River, June 27, 1909, *Butler 938* (MBG); Hornbrook, Siskiyou Co., July 6, 1903, *Copeland 3497*

(GH; US; MBG); Miller's Ranch, summit between Gilroy and Watsonville, May, 1903, *A. D. E. Elmer 4647* (US; MBG; OAC); Tassajara Hot Springs, June, 1901, *Elmer 3224* (MBG; US); Loma Prieta, Santa Clara Co., July 22, 1893, *Dudley* (DH); slope above Round Meadow, Fresno Co., 7300 ft., July 25, 1914, *Smiley 588* (GH); Sisson, Aug. 20, 1889, *Sheldon* (MBG; NYS); Grass Valley, 3000 ft., July, 1892, *Hansen 439* (MBG); Greenville, July 12, 1907, *Heller & Kennedy 8824* (US; GH; MBG); Willow Creek, Humboldt Co., June 16, 1918, *Abrams 7183* (DH); near Nevada City, July 14, 1905, *Heller 8113* (GH; US; type locality of *M. Sheltoni*); west side of Trinity River near Willow Creek, Humboldt Co., 600 ft., July 9, 1911, *Tracy 3476* (GH; US); Plumas Co., May, 1894, *Ames* (GH); Little Chico canyon, May, 1896, *Austin 803* (MBG; US); Russian River at Healdsburg, July 8, 1902, *Heller 5812* (MBG; GH; *type collection* of *M. coriacea* Heller); Napa, 1899, *Smyth* (GH; approaches the large-leaved forms of subsp. *euvillosa*, the same with the two following); Ukiah, April 22, 1891, *Fritchey* (MBG); Calaveras Big Tree Road, Aug. 1890, *Jepson 40 c* (J); Huntington Lake, Fresno Co., 7000 ft., *Grant 1157* (J); Vichey Springs, June 22, 1891, *Fritchey* (MBG); Summit, Butte Co., June 28, 1897, *Austin 1126* (US); Clio, Plumas Co., Aug. 27, 1910, *Eggleston 6213* (US); Little Chico Creek, 2000 ft., July 5, 1900, *Leiberg 5024* (US).

OREGON: Grant's Pass, June 24, 1884, *T. Howell 244* (GH; US); by the river, Grant's Pass, July 2, 1887, *T. Howell*, in part (OAC, 8981; MBG, 114312); gravel bar along Chetco River, 7 mi. above Harbor, Curry Co., July 19, 1919, *Peck 8910* (GH; MBG); by the river, Grant's Pass, July 2, 1887, *T. Howell* (MBG; NYS; OAC); Snow Camp, Curry Co., 4000–4250 ft., July, 1916, *Thompson 7* (DH); Cherry Creek Flat, Klamath Co., Aug. 15, 1908, *Rose 265* (DH); Grant's Pass, June 20, 1886, *Henderson 805* (OAC); Big Butte Creek Crossing, 30 mi. east of Medford, Jackson Co., Aug. 27, 1916. *Heller 12567* (MBG; GH; US; OAC; *type collection* of *M. amabilis* Heller); Sykes Creek, Jackson Co., July 14, 1892, *Hammond 325* (MBG); Takilma, Josephine Co., June 25, 1918, *Peck 7981* (GH); Wimer, Jackson Co., July 14, 1892, *Hammond 325* (US); Waldo, dry open forest of *Pinus ponderosa*, 1 mi. west of town, July 18, 1924, *Hall 11990* (UC).

M. dentata Rydb., based upon an unnumbered sheet in the Herbarium of the New York Botanical Garden, is unquestionably the plant which grows in the lower altitudes of the Sierra Nevada in central California. That it occurs on Gray's Peak in Colorado as reputed is very doubtful, and until further material is forthcoming such an extension of the range should not be made. It should be noted in this connection that Dr. Torrey visited the central Sierras several years earlier and that it is not impossible that an exchange of labels has taken place. The present printed label of the type sheet reads: "Herbarium of Columbia College, New York. Plants collected on Gray's Peak, Colorado Territory in August and September, 1872, by J. Torrey" and below in an unidentified hand "Monardella odoratissima Bth." The label is not contemporary with the collection. The plant thus labeled is strikingly like the collection of *M. villosa* subsp. *Sheltoni* made by Bridges in California (US; GH).

d. Subsp. **neglecta** (Greene), comb. nov.

Monardella neglecta Greene, Pittonia **5**: 82. 1902.

Madronella neglecta Greene, Leaflets Bot. Obs. **1**: 169. 1906.

Stems puberulent to glabrous in the inflorescence, purple; leaves ovate or oblong, obtuse, the blades 1–1.5 cm. long, subcuneate at the base, serrate in some at least, tapering into a petiole 2–5 mm. long; *bracts ovate, acute, membranous, only the outer foliaceous, and reflexed, the innermost purple, pubescent to glabrous, ciliate*, about equal to the calyces; calyx 6–8 mm. long, pubescent with spreading trichomes; corolla 12–14 mm. long, rose-purple, the lobes of the upper lip about one-half its length, that of the lower free nearly to the base.

Specimens examined:

CALIFORNIA: Mt. Tamalpais, 1876, *Vasey* (GH; US, TYPE of *M. neglecta* Greene); Tiburon, Marin Co., June 9, 1912, *Eastwood 315* (GH; US); Mt. Tamalpais, July 29, 1912, *Eastwood 1517* (GH; MBG; US); Crystal Springs Lake, June 23, 1913, *Suksdorf 312* (GH); south side of Mt. Tamalpais, July 17, 1913, *Suksdorf 581* (GH); Rock Spring Trail, Tamalpais, July 2, 1905, *K. Brandegee* (UC); Tiburon, Marin Co., on a rocky slope facing San Francisco Bay, June 3, 1909, *Walker 1727* (GH; MBG; US).

The specimen collected by Vasey on Mt. Tamalpais is cited

with the description of *M. neglecta* Greene. In the Greene Herbarium a fragment of this plant is mounted on the same sheet with a specimen collected by G. W. Dunn in Marin Co., July 22, 1890. The latter collection is designated as the type in Greene's handwriting. Only a photograph of this sheet has been seen by the author.

Subsp. *neglecta* is exceedingly variable, in habit, in pubescence, and in the texture of the bracts. When most vigorous it is scarcely to be distinguished from subsp. *Sheltoni.* A villous form, scarcely separable from subsp. *euvillosa* presumably collected with or near average plants, has been observed.

5. **M. hypoleuca** Gray, Bot. Calif. **2**: 476. 1880; Syn. Fl. N. Am., ed. 2, **2**[1]: 356. 1886; Abrams, Muhlenbergia **8**: 39. 1912; Davidson & Moxley, Fl. South. Calif. 314. 1923.

Monardella robusta Elmer, Bot. Gaz. **39**: 46. 1905.

Madronella hypoleuca Greene, Leaflets Bot. Obs. **1**: 169. 1906.

Perennial, suffrutescent, 30–50 cm. tall, erect or *trailing,* "prostrate or supported by other growth" (Elmer), the older stems glabrous, light brown, the bark checking longitudinally, the younger branches simple, purplish, villous near the glomerule; leaves *rhomboidal-lanceolate,* the smaller oblong, 2–4 cm. long, entire, obtuse, *green and glabrous above, the veins impressed, covered beneath with a white felt-like tomentum,* the margin revolute, petioles 3–10 mm. long; glomerules 3–4 cm. broad, compact, the bracts ovate, shorter than the calyces, membranous rather than foliar, but firm, tomentose; calyx 6–7 mm. long, scarious below, green and villous above, veins 13–15, teeth ovate-triangular, acute; corolla pale lavender or white, 15–16 mm. long, the tube 10 mm. long, the upper lip equal to or somewhat longer than the lower, the lobes about half its length, those of the lower lip one-fourth its length, tapering but little, blunt; stamens well exserted, the anthers divergent, the connective equilateral, well developed.

Specimens examined:

California: mountain drive, Santa Barbara, Aug. 21, 1904, *Abrams 4149* (GH); dry ridges, Santa Monica Mts., Topanga Canyon, June, 1907, *Hasse;* Rattlesnake Canyon, Santa Barbara, Aug. 1902, *Elmer 3728* (US; MBG; *type collection* of *M. ro-*

busta Elmer, TYPE in DH); San Bernardino Co. (Gray, Syn. Fl.), 1876, *Parry & Lemmon 330* (GH; TYPE); San Juan Capistrano, July, 1882, *Nevin 688* (GH); Malibu Canyon, Los Angeles Co., Aug. 5, 1898, *Barber* (UC); Rincon Cr., Ventura Co., Sept. 19, 1922, *Baer* (BH); trail, Trabuco canyon to Santiago Peak, Santa Ana Mts., Orange Co., 3000–4000 ft., Sept. 7, 1923, *Munz 7742* (BH).

6. M. lanata Abrams, Muhlenbergia 8: 39. 1912; Davidson & Moxley, Fl. South. Calif. 313. 1923.

Perennial, suffrutescent, 30–50 cm. tall, erect, branching at the base, the branches purplish, villous to lanate; *leaves oblong, the smaller even oblanceolate or subspatulate*, 2–4 cm. long, very obtuse, *short-pubescent to lanate above, the veins not prominent, covered beneath with a dense white felt-like tomentum, the margin strongly revolute*, petioles 3–10 mm. long; glomerules 3–4 cm. broad, compact, the bracts ovate, shorter than the calyces, membranous rather than foliar, but firm, tomentose; calyx 6–7 mm. long, scarious below, green above, lanately villous, veins 13–15, teeth ovate, triangular, acute; corolla pale lavender or white, 15–17 mm. long, the tube 10 mm. long, the upper lip equal to or somewhat longer than the lower, the lobes coalesced about half its length, those of the lower lip one-fourth its length, tapering but little, blunt; stamens well exserted, the anthers divergent, the connective equilateral, well developed.

Specimens examined:

CALIFORNIA: Descanso Grade near the top, July 19, 1906, *K. Brandegee* (UC, 104626, TYPE); Potrero Mts., July 23, 1883, *Orcutt 996* (GH; UC); San Diego Co., near Alpine, July 10, 1912, *Abrams 4896* (UC; US; BH; DH); Palomar Mt., back of Pala, July, 1901, *Schellenger* (UC; upper surface of leaves glabrate).

M. lanata is apparently distinct from *M. hypoleuca* which it most nearly resembles. The specimen collected by Schellenger suggests strongly a continuous range of variation between the two. If such is found to be the case when *M. lanata* is better known, it would best be considered as a subspecies of *M. hypoleuca.*

7. **M. viridis** Jepson, Fl. West. Middle Calif., ed. 1, 465. 1901, and ed. 2, 364. 1911.

M. ledifolia Greene, Pittonia **5**: 81. 1902.

Madronella ledifolia Greene, Leaflets Bot. Obs. **1**: 169. 1906.

Madronella viridis Arthur, Torreya **21**: 12. 1921.

Perennial from a short woody stem, branching at the base, erect, or decumbent, the sterile branches numerous, short, the fertile branches slender, 6–12 inches tall, whitish puberulent; leaves *rhomboidal lanceolate, 1–2 cm. long, obtuse, canescent with a minute but dense pubescence, dark green above, white beneath,* subentire, the margin distinctly and narrowly revolute, subcuneate at the base and narrowed to a margined petiole 2–3 mm. long; glomerules 2 cm. broad or less, globose, the bracts about equal to the calyces, membranous or subfoliar, firm, ovate-lanceolate, acute, softly pubescent; calyx 7 mm. long, rather shaggy-pubescent or villous; corolla 14–16 mm. long, the upper lip somewhat shorter, the lobes about half its length, those of the lower lip nearly free, *all tapering evenly,* but blunt; stamens subequal, about equal to the lips, the anthers small, *.75 mm.,* the sacs divergent, the connective equilateral.

Specimens examined:

CALIFORNIA: Sonoma County, ? 1894, *Krauss* (DH); Upper Conn Valley, Napa Range, Oct. 13, 1894, *Jepson 70d* (J, TYPE; fragment UC; TYPE of *M. ledifolia* Greene in Greene Herb.); Mt. St. Helena, 1893, *Jepson 32f* (J); Mt. Hanna, Lake Co., July 15, 1897, *Jepson 100j* (J).

M. ledifolia Greene is based upon the type collection of *M. viridis.* The species is distinct but apparently restricted to the St. Helena range.

8. **M. saxicola** Johnston, Bull. South. Calif. Acad. Sci. **28**: 19. 1921.

Perennial from decumbent, suffrutescent stems, branches erect, 30–40 cm. tall, branching below if at all, purple, puberulent; leaves *rhomboidal-lanceolate,* the smaller oblong, 2–5 cm. long, obtuse, *green and glabrous above,* pubescent beneath with a *silvery microscopic tomentum,* the margin revolute, the *veins impressed,* the blade narrowed at the base to a petiole 2–7 mm.

long; glomerules 2.5–3 cm. broad, bracts ovate, acute or obtuse, about equal to the calyx, membranous, but *firm* and rather thickish, pubescent; calyx 8–10 mm. long, rather slender, short-pubescent to villous, *veins 10–11*, teeth ovate-triangular, acute, hirsute within; corolla lavender to rose-purple, 14–17 mm. long, the tube 10 mm., the lobes ribbon-like but tapering slightly, blunt, those of the upper lip less than half its length, those of the lower lip three-fourths its length or more; stamens well exserted, the anther-sacs divergent, the connective equilateral, well developed.

Specimens examined:

CALIFORNIA: at start of old trail to the flats, near Brown's Flats, San Antonio Mts., 5000 ft., Sept. 1, 1918, *Johnston 2133* (BH, TYPE; DH); south spur of Cucamonga Peak, common among rocks on ridge crest, 5200 ft., June 30, 1918, *Johnston 2050* (DH; BH); head of Evey Canyon on Sunset Trail, San Antonio Mts., 4750 ft., July 1, 1917, *Johnston 1440* (BH).

Apparently distinct but very similar to *M. viridis* Jepson, from which it differs chiefly in leaf character, the leaves being larger, coarser, glabrous above, with a very minute, dense silvery tomentum on the lower surface. They are less cuneate and more rounded at the base and the veins are noticeably impressed. Since the author has seen no intergrading forms and since *M. saxicola* is geographically quite distant from *M. viridis*, it has seemed preferable to retain this as a species until it may be more extensively studied.

9. M. cinerea Abrams, Muhlenbergia 8: 33. 1912; Fl. Los Angeles, ed. 2, 317. 1917; Davidson & Moxley, Fl. South. Calif. 313. 1923.

Perennial, woody at the base, the stem covered with a brown bark which flakes and falls away; branches several, spreading, 5–15 cm. long, cinereous; leaves ovate-lanceolate, 5–11 mm. long, obtuse or acute, *denticulate* rather than serrate, sometimes entire, *cinereous or hoary on both surfaces with a soft subvillous pubescence giving the whole plant a bluish cast, sessile;* glomerules 1.5–2 cm. broad, compact, purplish, bracts ovate to elliptical, acute or shortly acuminate, about the length of the calyces, *membranous,*

pinnately veined, sparingly villous, purplish; calyx 7–9 mm. long, villous, 12–15-nerved, the teeth 2 mm. long, slender, acute, villous within; corolla rose-purple, 13–14 mm. long, lobes lanceolate, those of the upper lip two-thirds its length, those of the lower lip the length of the lip, the lower stamens slightly exceeding the lobes, a third longer than the upper pair, the anthers divergent, the connective equilateral, well developed.

Specimens examined:

CALIFORNIA: Little Baldy, 9500 ft., "common among the rocks," Aug. 22, 1917, *Johnston 1693* (GH; UC; BH); south slope of Baldy, 6000 ft., dry rocky ground, July 4, 1917, *Johnston 1422* (DH; GH; UC; BH); Icehouse Canyon, rocky places, 8300 ft., July 31, 1917, *Johnston 1458* (BH; UC); N. Fork San Antonio, 8000 ft., July 28, 1917, *Johnston 1571* (UC; BH); Mt. Baldy Lookout, 7000 ft., June 20, 1917, *Johnston 1261* (UC); Mt. Baldy, 8750 ft., July 4, 1917, *Johnston 1449* (UC); Mt. Baldy, 10,000 ft., July 4, 1917, *Johnston 1420* (UC); Mt. San Antonio (Mt. Baldy), 9000 ft. or more, July 24, 1901, *Abrams 1928* (BH; *type collection,* TYPE in DH); saddle between Baldy and Little Baldy, dry rocky slopes, 9400 ft., July 21, 1922, *Munz 6114* (BH); Mt. Baldy, 7500 ft., June 8, 1918, *Peirson 182* (J).

A very puzzling species of restricted habitat. The degree of variability within its altitudinal distribution is considerable, and while some forms suggest *M. linoides* subsp. *stricta* and others *M. odoratissima* subsp. *australis,* it still appears to be distinct.

§ SECTION III. ODORATISSIMAE

10. M. odoratissima Benth. Lab. Gen. et Sp. 332. 1834, in DC. Prodr. **12:** 190. 1848; Gray, Proc. Am. Acad. **11:** 101. 1876; Bot. Calif. **1:** 594. 1876; Syn. Fl. N. Am., ed. 2, 2^1: 357. 1886.

Perennial from a woody, often contorted and decumbent stem, the bark dark brown, splitting and falling away; branches erect or ascending, unbranched, seldom with short, erect, sterile branchlets in the upper nodes, of variable stature, 10–60 cm. tall, commonly 25–30 cm., pubescence close and short, canescent, or cinereous or glaucous-like, but never silvery; *leaves lanceolate,* varying,

on the one hand, to ovate and, on the other hand, to oblong, 1–3 cm. long, entire, rarely obscurely serrate, pubescent or glabrate, the pubescence *close and short*, never villous but *canescent, cinereous or glaucous-like*, never silvery, sessile or tapering behind to a petiole 1–3 mm. long (7 mm. in extreme forms); glomerules 1–5 cm. broad; bracts *membranous*, ovate or rotund, obtuse or acute, variously shaded with purple, densely short-villous or tomentose, or puberulent, strongly *ciliate on the margin* in most; calyx 6–10 mm. long, 13-nerved, scarious below, green and villous or hirsute above, teeth ovate, triangular, acute, hirsute within; corolla 1–2 cm. long, rose-purple to pallid, the tube retrorsely puberulent, the *lobes lanceolate rather than linear-oblong*, rounded to a rather obtuse point, those of the upper lip one-third to one-half its length, those of the lower lip seldom equaling it, for the most part about three-quarters its length; filaments retrorsely hispidulous at the base, the anther-sacs divergent, the connective equilateral, well developed; nutlets oval-oblong, about 2 mm.

Key to the Subspecies

A. Leaves appearing nearly or quite glabrous, tending to appear glaucous, usually more than 2 cm. long.
  a. Bracts tending to ovate or rotund, pubescent........subsp. *euodoratissima*
  b. Bracts tending to elliptical or oblong, puberulent..........subsp. *glauca*
B. Leaves distinctly pubescent.
  a. Leaves hoary, whiter beneath, pubescence dense in typical specimens....................................subsp. *discolor*
  b. Leaves cinereous or green, but not markedly whiter beneath.
    α. Bracts usually exceeding the calyces and short-acuminate................................subsp. *australis*
    β. Bracts equal to or shorter than the calyces, acute or obtuse.
      1. Glomerule .5–1.5 cm. broad, seldom 2 cm........subsp. *parvifolia*
      2. Glomerules 2–3 cm. broad, seldom less.
        I. Calyces woolly; pubescence about the same on both leaf surfaces.................subsp. *pallida*
        II. Calyces hirsute; pubescence on lower leaf surface usually longer and soft.......subsp. *pinetorum*

It was an unfortunate circumstance that the historical type of *M. odoratissima* should have been collected at the extreme northern station, not only for the species but for the genus and

in a locality which is not readily accessible. By reason of the great variability of the species, and because the described "type" was an extreme form and but little known, the synonymy which has grown up within the species is unusually large. If one were to consider the historical type-sheets alone, he might construct an artificial key which would satisfactorily separate not only those sheets but not a few others which by themselves appear "distinct." Yet when he came to apply such a key to extensive herbarium material or to the plants in the field, it is the author's opinion that the user of such a key would find himself driven to the creation of a still larger number of new "species" in order to classify his material consistently.

By reason of the fact that the species covers a wide range of territory, and since it does present differences in different parts of the range, an earnest but unsuccessful effort was made to find satisfactory criteria which would serve to divide the group into two or more clean-cut divisions. The subspecies here described represent the nearest approach to such an ideal. For convenience they might be called species and treated as such, yet it is the opinion of the author that no advantage would accrue, so numerous are the connecting forms, so profound is the effect of the environment, especially in numerous montane-desert stations where great extremes may occur within a relatively small radius of map distance and so close are the relationships of the subspecies.

a. Subsp. **euodoratissima,** nom. nov.

Monardella odoratissima Howell, Fl. Northwest Am. 550. 1901.

M. glabra Nutt., collected near Walla Walla, Mss., ex Benth. DC. Prodr. **12:** 190. 1848.

Madronella odoratissima Piper, Contr. U. S. Nat. Herb. **9:** 493. 1906; Piper & Beattie, Fl. Southeast. Washington, 216. 1914.

Branches thinly pubescent above, hardly cinereous; leaves lanceolate, tapering at the base but *subsessile*, averaging 2 cm., *green, appearing glabrous*, but shortly and sparingly pubescent; bracts ovate to rotund, about equal to the calyces, obtuse for the most part, pubescent on the veins, ciliate, *calyx woolly pubescent around the teeth;* corolla about 15 mm. long, the lobes slender.

Specimens examined:

Washington: near the narrows above Kettle Falls on the Columbia, *Douglas* (type at Kew, a portion and photograph at MBG); Meyers Falls, Stevens Co., Aug. 22, 1902, *Kreager 499* (US; GH; from the type locality and a very close match for the type); Blue Mts., June 26, 1897, *Horner 408* (US); Blue Mts., Columbia Co., July 26, 1897, *Horner B408* (GH; the same as the preceding ?); Blue Mts., Walla Walla Co., 5000 ft., Aug. 2, 1896, *Piper* (GH); Blue Mts., Walla Walla Co., July 15, 1896, *Piper* (BH); Colville Nat. Forest, 3500 ft., Aug. 6, 1912, *Wright* (US); near Mt. Hood on the Columbia R., Aug. 4, 1920, *Suksdorf 10568* (GH).

Oregon: Clearwater, no date, *Spaulding* (GH); no locality or date, *Geyer 468* (GH; cited by Bentham); Pendleton, dry thicket, July 16, 1915, *Peck* (GH); Blue Mts., between Ukiah and Long Creek, 4600 ft., July 26, 1917, *Lawrence 842* (DH; US); Gibbon (Bingham Springs Station), 530 m., June 28, 1916, *Eggleston 12845* (US); Milton, Umatilla Co., 1000 ft., Aug. 26, 1896, *Brown 43* (RMH; MBG; US); Elgin, Aug. 15, 1899, *Shear 5587* (US).

Nevada: Monitor Range, 8000 ft., Sept.–Oct., 1878, *Phillips & Sargent* (GH); 7 mi. east of Ely, 2400–3000 m., *Hitchcock 1306* (US); the two preceding are intermediate with subsp. *glauca*, but are perhaps closer to this.

New Mexico: Mogollon Mts., on or near the west fork of the Gila R., Socorro Co., 8500 ft., Aug. 23, 1903, *Metcalfe 565* (US; GH; MBG; can in no way be distinguished from the Blue Mt. plants).

b. Subsp. **discolor** (Greene), comb. nov.

Monardella discolor Greene, Pittonia **2**: 24. 1889; Howell, Fl. Northwest Am. 550. 1901.

M. nervosa Greene, Pittonia **4**: 322. 1901.

Madronella discolor Greene, Leaflets Bot. Obs. **1**: 169. 1906; Piper, Contr. U. S. Nat. Herb. **9**: 493. 1906; Piper & Beattie, Fl. Northwest Coast, 309. 1915.

Madronella nervosa Greene, Leaflets Bot. Obs. **1**: 169. 1906; Piper, Contr. U. S. Nat. Herb. **11**: 493. 1906.

Madronella odoratissima Greene, Leaflets Bot. Obs. **1**: 169. 1906; Rydb. Fl. Rocky Mts., ed. 2, 751. 1922.

Branches pubescent above, scurfy and cinereous, leaves *ovate-lanceolate*, tending to ovate, rather abruptly tapering behind but *subsessile*, averaging about 2 cm., often less, obscurely crenate-serrate, *hoary to cinereous with a dense minute tomentum;* bracts ovate or oblong, about equal to the calyces, obtuse, woolly-pubescent in typical specimens, at least pubescent, the margins strongly ciliate; *calyx woolly-pubescent;* corolla averaging about 13 mm., the lobes slender.

Specimens examined:

WASHINGTON: north fork of Cowiche Creek (Yakima region), July 21, 1901, *Cotton 464* (US); Alkali Lake, Douglas Co., 335 m., July 7, 1893, *Sandburg and Leiberg 413* (US); no locality stated, 1889, *Vasey 466* (GH; US); Wenatchee, July 28, 1896, *Whited 195* (US); White Bluff Ferry, Upper Columbia River, Aug. 11, 1892, *Lake & Hull 705* (GH; MBG); Rock Island, July, 1893, 2000–3000 ft., *Sandburg & Leiberg* (US; MBG; RMH); Yakima region, Cascade Mts., 1882, *T. S. Brandegee 235* (US; MBG; GH); Mt. Rainier, moraine of Cowlitz Glacier, in loose rock, 5000 ft., Aug. 1895, *Piper 2078* (US); Yakima, 1877, *T. J. Howell* (GH); bluffs east side of Columbia, below the Chelan, Oct. 13, 1880, *Watson 328* (GH; a specimen on the same sheet collected "on the bluffs of the Columbia R. above the Chelan, west side," Oct. 12, 1880, by the same collector and bearing the same number is very close to subsp. *euodoratissima*); stony bottoms of canyons, Rattlesnake Mts., 2500 ft., Aug. 2, 1902, *Cotton 760* (US; GH; MBG); along creek south of Ellensburg, June 27, 1897, *Whited 547* (US; OAC); gravelly banks of the Yakima near Clealum, Aug. 13, 1889, *Greene* (FM; UC; *type collection* of *M. discolor* Greene); gravelly shores of Yakima River, June, 1897, *Elmer 373* (US; MBG; annoted by Greene as being "*M. discolor* Greene exactly and from near original station"); southeast side of Mt. Rainier, 7000 ft., *Allen* (GH); Ellensburg, July, 1898, *Elmer* (MBG); Mt. Adams, 6000–7000 ft., Aug. 31, 1882, *Suksdorf* (FM); Umtanum Creek, Yakima Co., July 26, 1923, *St. John 3108* (S); Coulee City, Grant Co., June 25, 1923, *St. John 3107* (S); 18 mi. north of Yakima, dry stony soil in belt of *Purshia* and *Artemisia tridentata*, July 23, 1924, *Hall 12009* (UC).

OREGON: Mt. Hood, among rocks, 6500 ft., Aug. 25, 1899,

Barber (GH; RMH); The Dalles, June, 1881, *T. Howell* (OAC); no locality, collected by (?) *Cooper, Stevens Exp.* (GH). The following specimens from eastern Oregon are most nearly related to *M. odoratissima* subsp. *discolor* but have the pubescence much reduced, in this respect resembling subsp. *glauca;* the habit, shape of the leaves and general aspect is that of subsp. *discolor*, however; some suggest subsp. *euodoratissima:* Gilliam Co., near forks of Cottonwood Canyon, 3400 ft., Sept. 7, 1894, *J. B. Leiberg 885* (US; GH; UC); near dry run between Bear Buttes and Button Springs, Crook Co., 4400 ft., Aug. 24, 1894, *J. B. Leiberg 797* (US; GH; FM; UC); White Horse Mts., Aug., 1901, *D. Griffiths & E. L. Morris 416* (US); near Guano Ranch, Harney Co., 4350 ft., July 24, 1896, *F. V. Coville & J. B. Leiberg 9* (US).

c. Subsp. **glauca** (Greene), comb. nov.

Monardella glauca Greene, Pittonia **4**: 321. Nov. 7, 1901.

M. modocensis Greene, Pittonia **4**: 321. Nov. 7, 1901.

M. purpurea Howell, Fl. Northwest Am. 550. Nov. 20, 1901.

M. rubella Greene, Pittonia **5**: 84. 1902.

M. ovata Greene, Pittonia **5**: 82. 1902.

M. ingrata Greene, Pittonia **5**: 83. 1902.

Madronella modocensis Greene, Leaflets Bot. Obs. **1**: 169. 1906.

Madronella rubella Greene, Leaflets Bot. Obs. **1**: 169. 1906.

Madronella glauca Greene, Leaflets Bot. Obs. **1**: 169. 1906.

Madronella ovata Greene, Leaflets Bot. Obs. **1**: 169. 1906.

Madronella oblongifolia Rydb. Bull. Torr. Bot. Club **36**: 686. 1909; Fl. Rocky Mts., ed. 2, 751. 1923.

Madronella sessilifolia Rydb. Bull. Torr. Bot. Club **36**: 685. 1909; Fl. Rocky Mts., ed. 2, 751. 1923.

Madronella purpurea A. Nelson, Bot. Gaz. **52**: 71. 1911.

Madronella ingrata Greene, Leaflets Bot. Obs. **1**: 169. 1906.

Branches puberulent, usually *glaucous-appearing*, purple or whitish; leaves ovate-lanceolate, elliptical or oblong, 1.5–4 cm. long, seldom truly ovate, variable on the same plant in size and shape, *narrowed at the base to a margined petiole* 1–5 mm. long, glabrate, commonly *glaucous-appearing* due to a microscopic puberulence, the uppermost leaves commonly subsessile; bracts ovate, with a tendency for the outer to become orbicular and *the inner oblong*, puberulent, purplish, ciliate; calyx pubescent,

hirsute around the teeth, seldom woolly; corolla 1–2 cm. long, the lobes noticeably tapering.

Specimens examined:

OREGON: summit of Cascade Mts., Ashland-Klamath Falls Rd., July, 1920, *Peck 9265* (GH; MBG); coast mountains near Waldo, June 13, 1884, *T. J. Howell* (US; GH; type locality of *M. purpurea* Howell and not improbably the collection referred to by him); Ashland, July 8, 1886, *Henderson 805* (OAC); Cherry Creek, 4150 ft., dry woods, July 23, 1899, *Leiberg 4306* (US); rocky peak 12 mi. southeast of Port Orford, July 25, 1919, *Peck 8934* (MBG; GH); Siskiyou Mts., 12 mi. south of Waldo, July 2, 1918, *Peck 8396* (GH); 8 mi. south of Waldo, June 14, 1904, *Piper 6234* (US); Eight Dollar Mt., Josephine Co., June 12, 1904, *Piper 5341* (US); Eastern Cascade Mts., Klamath Co., June 30, 1902, *Cusick 2846* (GH; MBG; US); 2 mi. southeast of Oregon Caves, Josephine Co., July 16, 1918, *Peck 8369* (GH); Keno, Klamath Co., July 9, 1920, *Peck 9413* (GH); Buck Lake, Klamath Co., July 24, 1897, *Coville & Applegate 14* (US); Siskiyou Mts., July 8, 1887, *T. Howell 1250* (NYS; OAC; MBG); Siskiyou, 4100 ft., June 26, 1920, *Fischer 38* (US); Baker Co., dry run of canyon of East Pine Creek, 3 mi. northeast of Cornucopia, Aug. 27, 1915, *Peck 5538* (GH); eastern Oregon, June 21, 1898, *Cusick 1956* (GH; MBG; US; *type collection* of *M. glauca* Greene); Wallowa Co., east of Tollgate Ranger Station, Wenaha Nat. For., 4500 ft., Aug. 3, 1916, *Lawrence* (US).

CALIFORNIA: Mt. Shasta, Sept. 7, 1897, *Canby 221* (GH; US); Gold Lake, Sierra Co., 1960 m., Aug. 28–29, 1910, *Eggleston 6272* (US; this and the next have the inflorescence characters of subsp. *pallida* and the herbage of subsp. *glauca*); Gold Lake, Sierra Co., 1960 m., Aug. 28–29, 1910, *Eggleston 6269* (US); Siskiyou Co., Mt. Eddy, 4500 ft., July 16, 1915, *Heller 12105* (US; GH; OAC; MBG; US); Baxter Gulch, Trinity Co., June 17, 1914, *Yates 441* (UC); Siskiyou Co., Mt. Hilt, *Rexford* (US); Shasta Co., near Bald Mt., south of Fall River Mills, 3800 ft., June, 1903, *Hall & Babcock 4262* (DH); south fork of the San Joaquin River, Fresno Co., 6700 ft., July, 1900, *Hall & Chandler 638* (US; MBG); Yreka, Aug., 1876, *Greene* (FM; authentic material of *M. modocensis* Greene); Buck Mt., near Summit, Humboldt Co., 5500 ft.,

July 31, 1912, *Tracy* (UC; US; suggests subsp. *pallida*); Butte Co., Chico Meadows, 4000 ft., *Heller 11604* (OAC; GH; US; part of the collection suggests *M. villosa* subsp. *Sheltoni*); Butte Co., near Stirling, 3400 ft., June 7, 1913, *Heller 10792* (GH; US; MBG); Siskiyou Co., Humbug Mt., 4000 ft., May 23, 1910, *Butler 1393* (US; RMH; MBG; GH); Gasquet, French Hill, Del Norte Co., Sept. 14, 1912, *Eastwood 2200* (US; GH); ridge between Eagle & Bear Mt., Modoc Forest, 8000 ft., Aug. 18, 1918, *Smith 1046* (J); Clear Creek, Butte Co., near Cherokee, 175 feet., Apr. 15–30, 1897, *Brown 43* (US); Yreka, June 30, 1876, *Greene 910* (MBG; authentic material of *M. modocensis* Greene); Sisson, Siskiyou Co., 3555 ft., June 1–10, 1897, *Brown 381* (MBG; US; *type collection* of *M. ovata*, TYPE in US, an extreme form); Shasta Springs, Siskiyou Co., June 13, 1905, *Heller 8018* (GH; US); Dorleska, Trinity Co., 6500 ft., July, 1909, *Hall 8602* (US); Hot Spring Valley, Plumas Co., July 7, 1897, *Austin 1123* (US); Mt. Bidwell, Modoc Co., Aug. 27, 1903, *Manning 350* (US; suggests subsp. *discolor* as it occurs in eastern Oregon); Tuolumne Meadows on south gravelly slopes at base of granite dome, at cascades of Dana Fork, 8700 ft., Aug. 5, 1923, *Hall* (UC); Middle Fork San Joaquin River, 7600 ft., open slopes of *Abies magnifica* forest near Hot Spr., Aug. 30, 1923, *Hall 11891* (UC; inflorescence of subsp. *glauca*, foliage of subsp. *pallida*).

NEVADA: Washoe Co., log railroad north of Verdi, 5300 ft., June 30, 1913, *Heller 10891* (GH; US; MBG; type locality of *M. rubella;* the plants of this collection closely resemble the type); Washoe Co., Hunter Creek, 6000 ft., Aug. 2, 1912, *Kennedy* (US; GH; MBG); Washoe Co., Mt. Rose, 9300 ft., Aug. 26, 1911, *Heller 10346* (US; GH; MBG); Reno, 4500 ft., June 11, 1897, *Jones* (MBG; US); Virginia City, 1863, *Bloomer* (US); Reno, 5000 ft., June 19, 1900, *Stokes* (DH); Genoa, Douglas Co., June 15, 1889, *Lt. Bryan's Exp.* (MBG); Summit Lake Region, July, 1901, *Griffiths & Morris 328* (US); hills, northeast of Reno, 6000 ft., June 20, 1900, *Stokes* (US). The following have the foliage of subsp. *glauca* but approach subsp. *pallida* in the nature of the inflorescence: Hunter's Canyon, vicinity of Reno, 1350–1500 m., July 18, 1913, *Hitchcock 529* (US); Marlette Peak, Washoe Co., 8000 ft., July, 1903, *Hall & Chandler 4567* (US);

King's Canyon, Ormsby Co., 1700–2000 m., June 21, 1902, *Baker 1113* (RMH; US; MBG; GH; referred to *M. glauca* by Greene); Franktown, Washoe Co., 5000 ft., June 28, 1909, *Heller 9795* (GH). The following are intermediate between the longer-petioled forms of California and Nevada and the more nearly sessile forms with oblong leaves, of Utah: Battle Mountain, 1350 m., July 22, 1913, *Hitchcock 576½* (US); Allegheny Creek, 8000 ft., Aug. 6, 1912, *Nelson & Macbride 2172* (US; MBG; GH; RMH); Gold Creek, 6300 ft., July 29, 1912, *Nelson & Macbride 2130* (GH; MBG; US); Ruby Mts. near Blaine P.O., 9300 ft., Aug. 22, 1913, *Heller 11109* (US; GH; MBG); Kingston Canyon, Landor Co., Toiyabe Range, 7500 ft., July 28, 1913, *Kennedy 4202* (GH; the Toiyabe range proper is in Nye Co.); Bunker Hill, Toiyabe Forest, 2250–3400 m., July 29, 1913, *Hitchcock 877* (US).

MONTANA: Mt. Logan, Aug. 1895, *Shear 3164* (US).

IDAHO: Oneido Co., top of ridge on the west of Franklin Basin, July 25, 1910, *Smith 2286* (US); Caribou Forest, Aug. 4, 1913, *Young* (US); Owyhee Co., Silver City, 7000 ft., July 19, 1910, *Macbride 434* (US; GH; RMH; MBG).

COLORADO: Elk Mountains, Pittsburgh, Aug., 1889, *Eastwood* (CSM); Ouray, Ouray Co., Horsethief Trail, July 25, 1915, *Osterhout 5352* (RMH; inflorescence of subsp. *parvifolia*).

UTAH: Cottonwood Canyon near Salt Lake, Sept. 7, 1896, *Stokes* (DH); Clayton Peak, 10,000 ft., Wahsatch Mts., Aug. 12–26, 1903, *Stokes* (US; MBG); Fish Lake, 10,000 ft., Aug. 7, 1894, *Jones 5768* (MBG; US); Aquarius Plateau, 11,000 ft., Aug. 11, 1875, *Ward 549* (MBG; US); Alta, 8500 ft., July 17, 1880, *Jones* (US); 12-mile canyon, Wahsatch Mts., 2700 m., Sept. 3, 1907, *Tidestrom 477* (US); Aquarius Plateau, Aug. 5, 1905, *Rydberg & Carlton 7464* (US); Marysvale, Tate Mine, 11,500 ft., Aug. 28, 1894, *Jones 5940* (US); Wahsatch Mts., 8200 ft., July 18–24, 1902, *Pammel & Blackwood 3782* (GH; MBG); grassy slopes, La Sol Mts., 9000–10,000 ft., July, 1899, *Purpus 6694* (MBG; US); City Creek Canyon, July 17, 1880, *Jones* (RMH); Big Cottonwood Canyon, 10,000 ft., Aug. 7, 1902, *Cooper 348* (RMH); Mt. Terrell, Wahsatch Mts., 3285 m., Aug. 27, 1908, *Tidestrom 1829* (US); Big Cottonwood Canyon, 9000 ft., July 12, 1905, *Garrett*

1404 (US); Abajo Mts. (eastern range), 3000–3300 m., Aug. 17, 1911, *Rydberg & Garrett 9723* (US; RMH); Pine Valley Mts., 7000–8000 ft., May–Oct., 1898, *Purpus 6198* (US); Mt. Nebo, Aug. 15, 1905, *Rydberg & Carlton 7706* (RMH; US; *type collection* of *M. oblongifolia* Rydb., TYPE in N. Y. Bot. Gard.); mountains north of Bullion Creek, above Marysvale, July 23, 1905, *Rydberg & Carlton 7178* (RMH; GH; US); Wahsatch Mts., American Fork, 1877, *Hooker & Gray* (GH); Alta, Wahsatch Mts., 10,000 ft., July 30, 1879, *Jones 1109* (GH).

ARIZONA: Coconino Nat. For., 7900 ft., July 9, 1909, *Pearson 245* (US; inflorescence that of subsp. *parvifolia*).

d. Subsp. **pallida** (Heller), comb. nov.

Monardella pallida Heller, Muhlenbergia **1**: 36. 1904.

Madronella pallida Heller, Muhlenbergia **1**: 138. 1906.

Branches *scurfy-pubescent, cinereous,* but not glaucous-appearing, whitish rather than purple, leaves lanceolate-oblong, 2–3 cm. long, somewhat rounded at the base and narrowed to a *usually margined petiole* 2–8 mm. long, the upper seldom appearing sessile, cinereous with a minute pubescence, but not glaucous-like; bracts *inconspicuous,* broadly ovate, short-pubescent, often woolly, purplish, ciliate, seldom exceeding the calyces, *often decurved* but not reflexed; *calyx short, woolly, often densely so throughout,* the glomerules hence appearing very compact; corolla 1–1.5 cm. long, pallid, the lobes noticeably tapering; tube little or not at all exserted.

Specimens examined:

CALIFORNIA: Round Meadow Camp, Sierra Nevada Mts., 7000 ft., July, 1902, *Grant 2030* (US); ridge near the lower end of Donner Lake (south side), July 17, 1903, *Heller 6959* (GH; US; MBG; *type collection* of *M. pallida* Heller); Kaiser Crest, base of south slope, 8600 ft., July 27, 1914, *Smiley 616* (GH); Clio, Plumas Co., 2080 m., Aug. 27, 1910, *Eggleston 6281* (US); Gabbot Meadow, Stanislaus Forest, Alpine Co., 1970 m., June 19, July 19, 1913, *Eggleston 9689* (US); Gold Lake Trail, Clio, Plumas Co., 1800 m., Aug. 27, 1910, *Eggleston 6246* (US); Farwell Gap, 10,400 ft., Apr.–Sept., 1897, *Purpus 5224* (GH; MBG; US); above Giant Forest, Sequoia Nat. Park, Aug. 24, 1899, *Copeland 19* (US); Grass Lake (Lake Tahoe Region), Aug. 8, 1909, *Mc-*

Gregor 3 (GH; US); Butte Co., Summit above Jonesville, 7000 ft., July 29, 1917, *Heller 12860* (MBG; OAC; US); Camp Echo, Eldorado Co., on the Lincoln Highway, 7000 ft., *A. A. Heller, 12186* (MBG; OAC); Prattville, Plumas Co., *Heller & Kennedy 8774* (GH; US; MBG); Summit, Alpine Co., 9000 ft., Aug., 1892, *Hansen 438* (MBG); Bear River, 5500 ft., Amador Co., July 30, 1896, *Hansen 1934* (US); Scott's Mt., 4000–7000 ft., Aug. 29, 1880, *Engelmann* (MBG); Horse Camp, Mt. Shasta, Aug. 12, 1920, *Heller 13515* (US; MBG); Donner Pass, Placer Co., 7200 ft., July 26, 1919, *Heller 13320* (GH; MBG; US); Eldorado Co., east side of Ralston Peak, above Echo Lake, 7900 ft., Aug. 10, 1911, *Heller 12536* (GH; MBG; OAC; US); vicinity of Tuolumne Meadows, Tuolumne Co., 8500–9500 ft., July 1902, *Hall & Babcock 3626* (DH; perhaps better as subsp. *glauca*); Aspen Grove, Lake Tahoe region, July, 1911, *Hawver* (US); Yosemite Nat. Park, July 21–22, 1915, *Hitchcock* (US); Eagle Lake, Lassen Co., July 28, 1894, *Baker & Nutting* (RMH); south side of Mt. Shasta, 5000–10,000 ft., July 15–31, 1897, *Brown 570* (US; MBG); Plumas Co., 1876, *Ames* (MBG); Mt. Shasta, 6000 ft., Aug. 22, 1880, *Engelmann* (MBG); Colby, Butte Co., July, 1896, *Austin 289* (US); headwaters of Hat Creek, Shasta Co., 2120 m., July 31–Aug. 1, 1911, *Eggleston 7457* (US); near Donner Pass, 1865, *Torrey 403b* (US); Mt. Shasta, July 13–27, 1892, *E. Palmer 2508* (US); Nevada Co., 6300 ft., Aug.–Sept., 1893, *Carpenter* (US); Cisco, Placer Co., 6000 ft., July 1, 1910, *Hall 8731* (US); Mt. Shasta, 8000 ft., Aug.–Sept., 1902, *Grant 796* (US); Mt. Shasta, 9000 ft., Aug. 28, 1889, *Munson & Hopkins* (US); McKinney's, Lake Tahoe, Aug., 1900, *De Con 428* (US); Mt. Shasta, 5000–9000 ft., Sept. 13, 1862, *Brewer 1386* (US); Mineral King, Tulare Co., 2750 m., July 31, 1891, *Coville & Funston* (US); Tar Gap region, Tulare Co., Aug. 2, 1904, *Culbertson 4448* (MBG; GH); Angora Peak, north slope, 7600 ft., July 14, 1913, *Smiley 7* (GH); Sierra Nevada, 1875, *Muir* (MBG); Luthers Pass, 7800 ft., July 27, 1911, *Abrams 4760* (US; GH); Truckee, Nevada Co., June, 1886, *Sonne 284* (FM); Goose Valley, Shasta Co., June 29, July 11, 1912, *Eastwood 770* (GH; herbage of subsp. *glauca* and inflorescence of subsp. *pallida*); Greenhorn Pass, 5000–6000 ft., Apr., Sept. 1897, *Purpus 5532* (US); Truckee, 1750 m., July 14,

1913, *Hitchcock 316* (US); Pine Ridge, Fresno Co., 5200 ft., June 15–25, 1900, *Hall & Chandler 286* (MBG; US; suggests subsp. *pinetorum* somewhat); Rancheria Mt., north of Tuolumne R., 8500 ft., July 24, 1909, *Jepson 3404a* (J); South Yallo Bolley, July 2, 1897, *Jepson 100i* (J; "flowers nearly white—merely lilac-tinged"); Mt. Shasta, near snow line, Aug. 4, 1894, *Jepson 59f* (J.); Kennedy's meadow, Tuolumne Co., 6700 ft., Aug. 4, 1916, *Grant 896* (J; herbage of subsp. *glauca* and inflorescence of subsp. *pallida*); Huntington Lake, Fresno Co., 7000 ft., July 20, 1917, *Grant* (J); Campito Mt., White Mts., 10,700 ft., July 25, 1917, *Jepson 7286* (J).

Nevada: Galena Creek, Mt. Rose, Washoe Co., 8000 ft., Aug., 1906, *Kennedy 1236* (US). The following have the inflorescence of subsp. *pallida*, or approach it more closely, but in herbage suggest subsp. *glauca:* Mt. Rose, Washoe Co., 9700 ft., Aug. 26, 1911, *Heller 10345* (GH; MBG; US); Clear Creek Canyon, Ormsby Co., 2000–2615 m., July 22, 1902, *Baker 1347* (MBG; GH; US).

Oregon: Keno, Klamath Co., July 9, 1920, *Peck 9413* (MBG); Mt. Pitt (Jackson-Klamath Co.), Aug. 16, 1896, *Gorman 457* (US); Gayhart Buttes, 2100 m., Aug. 7, 1896, *Coville & Leiberg 266* (US).

e. Subsp. **pinetorum** (Heller), comb. nov.

Monardella pinetorum Heller, Muhlenbergia **1:** 36. 1904.

Madronella pinetorum Heller, Muhlenbergia **1:** 138. 1906.

Branches softly pubescent, not glaucous-appearing, leaves ovate to lanceolate, 1.5–2.5 cm. long, somewhat rounded at the base, tapering to a usually *margined petiole* 2–8 mm. long, the upper seldom appearing sessile, *softly pubescent*, even to subvillous principally *on the under surface*, the margin usually revolute and obscurely crenate-dentate or entire; bracts inconspicuous but erect, equaling the calyces, ovate, *short-pubescent*, purplish, ciliate; calyx pubescent, the hairs spreading and not curling; corolla 1.0–1.5 cm. long, rose-color, the lobes noticeably tapering, the tube exserted 1–2 mm.

Specimens examined:

California: southern slope of Mt. Sanhedrin above the saw-mill, July 19, 1902, *Heller 5909* (MBG; GH; US); near Slap Jack

Camp, west of alder springs, 5000 ft., Glenn Co., July 5, 1917, *Heller 12810* (OAC; US; MBG; GH; *type collection* of *M. pinetorum* Heller); south fork Kaweah River, Tulare Co., July 22, 1904, *Culbertson 4477* (GH; MBG); McCombers, Aug. 1, *Newberry* (US); Longworthys, near North Fork, 4500 ft., July 16, 1912, *Abrams 4951* (GH; DH; suggests *M. villosa*).

This group strongly suggests hybridization with *M. villosa.*

f. Subsp. **parvifolia** (Greene), comb. nov.

Monardella parvifolia Greene, Pl. Baker. **3**: 22. 1901.

Monardella muriculata Greene, Pittonia **5**: 84. 1902.

Madronella parvifolia Rydb. Bull. Torr. Bot. Club **33**: 150. 1906.

Madronella muriculata Greene, Leaflets Bot. Obs. **1**: 169. 1906.

Monardella parviflora Nelson in Coulter & Nelson, Manual Central Rocky Mts. 430. 1909 (not Greene; in error for *M. parvifolia* Greene).

Branches *scurfy-pubescent, cinereous, slender,* seldom puberulent and purplish; leaves lanceolate or oblong, *1–2 cm. long,* tapering at the base to a margined petiole 1–3 mm. long, *cinereous,* but not glaucous-appearing, with a sparse, short pubescence; glomerules small for the species, *1–2 cm. broad, bracts inconspicuous,* seldom exceeding the calyces, ovate, acute, or shortly acuminate, pubescent, even shortly villous, ciliate; calyx 5–6 mm. long, *pubescent, sparingly villous around the teeth;* corolla seldom exceeding a centimeter in length.

Specimens examined:

California: foot of Mt. Whitney, 12,000 ft., Sept. (in flower), 1875, *Rothrock 42* (US; GH); near Whitney Meadows, Aug. 20, 1891, *Coville & Funston 1646* (US); along Big Cottonwood Creek (Inyo Co.), Aug. 4, 1891, *Koch 2158* (US); Ebbets Pass, on dry mountain top, 8500–9000 ft., Aug. 1, 1863, *Brewer 2006* (US); Tuolumne Meadows, dry ledges, 8600 ft., July 20, 1907, *Ware 2658* (GH); Mammoth Lakes just below Mary's Lake, 8900 ft., "In small openings in the subalpine forests of *Abies magnifica* and *Pinus monticola,* with *Chrysopsis Breweri, Ceanothus velutinus, Gilia aggregata* and *Haplopappus Bloomeri,*" Aug. 30, 1923, *Hall 11893* (UC); Junction Camp to Whitney, head of Kern Canyon, 9500 ft., Aug. 1–12, 1900, *Jepson 1055* (J).

Nevada: Morey Peak, 7000–8000 ft., May–Oct. 1898, *Purpus 6369* (US); Star Peak, 8500 ft., Sept. 1867, *Watson 826* (US; a second collection bearing the same collection number was made from E. Humboldt Range, 8000 ft., Aug. 1868; both are similar and are the plants referred to by Watson in the Botany of the King's Expedition). The plant described by Greene as *M. muriculata* was from the same locality and the plant of Watson from Star Peak resembles Greene's type closely.

Arizona: near Sunset Peak, 6000 ft., July 13, 1901, *Leiberg 5698* (US); Flagstaff, May–Oct. 1900, *Purpus 8089* (US; MBG); San Francisco Mts., crater at 10,000 ft., July 16, 1913, *Goldman 2132* (US); Schulze's Ranch, 8000 ft., San Francisco Mts., July 7, 1891, *MacDougal 404* (US; suggests subsp. *euodoratissima*); San Francisco Mts., 9000 ft., Aug. 3, 1898, *MacDougal 363* (GH; RMH; US); hillsides along the northern foot of San Francisco Mts., 5550 ft., July 1, 1901, *Leiberg 5620* (US; suggests subsp. *glauca*); northern slopes of San Francisco Mts., 5500 ft., Aug. 29, 1901, *Leiberg 5906* (US); near Kendrick Mts., 6600 ft., July 7, 1901, *Leiberg 5653* (US).

Colorado: Black Canyon near Sapinero, 7200 ft., Sept. 1893, *Purpus 726* (FM); Black Canyon, 7000 ft., Aug. 1, 1901, *Baker 678* (RMH; US; GH; MBG; *type collection* of *M. parvifolia* Greene); Placerville, June 23, 1917, *Payson 1097* (MBG); Black Canyon, July 30, 1917, *Bethel* (CSM); El Late (Ute) Mts., Aug. 1875, *Brandegee 1224* (MBG).

New Mexico: near Mogollon, Mogollon Mts., Socorro Co., Aug. 8, 1900, *Wooton* (US; RMH).

g. Subsp. **australis** (Abrams), comb. nov.

Monardella australis Abrams, Muhlenbergia 8: 34. 1912; Davidson & Moxley, Fl. South. Calif. 313. 1923.

Branches *decumbent or ascending*, seldom erect, sparsely pubescent, *subvillous;* leaves lanceolate or oblong, often acute, green or cinereous, but not glaucous-like or silvery, 1–2.5 cm. long, narrowed at the base to a petiole 1–3 mm. long; bracts lanceolate, *exceeding the calyces, short-acuminate*, whitish or purple, puberulent, frequently with a sparse pubescence in addition, the margin ciliate, but not strongly; corolla about 1.5 cm. long, the lobes slender, tapering, but not greatly.

Specimens examined:

CALIFORNIA: San Bernardino Mts., 1880, *Nevin* (GH); San Jacinto Mt., 8000–10,000 ft. (6000–10,000 ft. on some sheets), July 22, 1917, *Hall 713* (UC; DH; US); on trail to summit of Round Valley, 9300 ft., July 11, 1908, *Reed 2420* (US); in open forests of Tamarack Valley, 9200 ft., July, 1901, *Hall 2486* (UC; BH; MBG; *type collection* of *M. australis* Abrams, TYPE in DH); San Bernardino Mts., Aug. 1884, *S. B. & W. F. Parish 462* (MBG); High Creek, San Bernardino Mts., 9100 ft., Aug. 23, 1923, *Munz 7629* (BH); north side of Mt. Waterman, Aug. 29, 1917, *Grinnell* (BH); Tahquitz Valley (San Jacinto Mts.), no data (BH); Box Springs on City Creek Road, 4800 ft., June 8, 1919, *Johnston 2894* (BH); slope above Tamarack Valley, 10,000 ft., Sept. 7, 1922, *Munz 6409* (BH); Little Bear Valley, 5300 ft., July, 1899, *Hall 1298* (UC); San Jacinto Mt., Aug. 1881, *S. B. & W. F. Parish 462* (GH; MBG; FM; the latter is dated July, 1881, from San Bernardino Mts., but bears the same number); Mt. Grayback, San Bernardino Mts., June, 1880, *Wright* (GH); Tahquitz Creek above Walters, San Jacinto Mts., July 10, 1909, *Wilder 2 & 3* (UC); Deep Creek, San Bernardino Mts., July 30, 1901, *Abrams 2046* (DH); Little Bear Valley, 5000 ft., July 22, 1897, *Chandler* (UC); Mill Creek Divide, San Bernardino Mts., 8000 ft., *Robertson 107* (UC); Tahquitz Valley, San Jacinto Mts., July 10, 1909, *Wilder 1* (UC); slope of San Jacinto Creek, 10,300 ft., *Jepson 2314* (J); Tahquitz Valley, San Jacinto Mt., 8000 ft., *Jepson 2295* (J).

Some forms suggest *M. macrantha* var. *tenuiflora* but differ in the flower.

11. M. linoides Gray, Proc. Am. Acad. **11**: 101. 1876; Bot. Calif. **1**: 594. 1876; Syn. Fl. N. Am., ed. 2, **2**^{1}: 357. 1886.

Perennial from a woody, usually decumbent, branching stem, the bark light brown, checking and falling away; branches erect, their arrangement often candelabra-like, rebranching below, if at all, 30–50 cm. tall, *pubescence minute, close, silvery;* leaves *narrowly oblong, oblong, or narrowly lanceolate,* 1–4 cm. long, acute or obtuse, entire, narrowed to a petiole 2–4 mm. long, the uppermost appearing sessile, the *lowermost obovate or spatulate,* all

covered with a minute *silvery* pubescence; glomerules 2–3 cm. broad, bracts ovate to lanceolate, acuminate, equalling or exceeding the calyces, scarious-membranous, whitish puberulent or tinged with rose to purple, the margin subciliate; calyx 6–10 mm. long, 13-nerved, even throughout and rather slender, closely puberulent to rather sparingly hirsute, especially above, teeth slender, hirsute within; corolla 12–15 mm. long, rose-purple or pallid, the lobes slender, tending to oblong rather than lanceolate, blunt, tube retrorsely puberulent within and without, the lips subequal, the lobes of the upper about one-half its length, those of the lower lip nearly or quite free, filaments retrorsely hispidulous towards the base, but variable, anther-sacs divergent, the connective equilateral, well developed.

Key to the Subspecies

A. Bracts ovate to rotund, whitish .... subsp. *eulinoides*
B. Bracts lanceolate, purple-colored .... subsp. *stricta*

a. Subsp. **eulinoides,** nom. nov.

Monardella linoides Abrams, Muhlenbergia **8:** 37. 1912; Davidson & Moxley, Fl. South. Calif. 313. 1923.

M. viminea Greene, Pittonia **5:** 85. 1902; Abrams, Muhlenbergia **8:** 37. 1912; Davidson & Moxley, Fl. South. Calif. 313. 1923.

M. oblonga Greene, Pittonia **5:** 83. 1902; Abrams, Muhlenbergia **8:** 38. 1912; Davidson & Moxley, Fl. South. Calif. 313. 1923.

M. anemonoides Greene, Pittonia **5:** 86. 1902.

Madronella linoides Greene, Leaflets Bot. Obs. **1:** 169. 1906.

Madronella viminea Greene, Leaflets Bot. Obs. **1:** 169. 1906.

Madronella oblonga Greene, Leaflets Bot. Obs. **1:** 169. 1906.

Madronella anemonoides Greene, Leaflets Bot. Obs. **1:** 169. 1906.

Herbage silvery, with a close minute puberulence, the leaves narrowly oblong or narrowly lanceolate; bracts *broadly ovate, shortly acuminate, whitish puberulent,* infrequently tinged with purple, occasionally pubescent, surpassing the calyces, *not infrequently enveloping them; calyx puberulent* or sparingly hispid;

lobes of the corolla tending to narrowly oblong, tapering but little, the upper lip usually incised to about one-half its length.

Specimens examined:

CALIFORNIA: Oriflamme Mine, near San Diego, July 28, 1875, *E. Palmer 261* (*?296*) (GH, TYPE; MBG; UC); Oriflamme Canyon near Cuyamaca, June 28, 1903, *Abrams 3932* (US; GH; MBG; BH); Tahquitz Valley, San Jacinto Mts., 7000 ft., June-July, 1901, *Hall 2430* (US; UC; MBG); 20 mi. south of Palm Springs, July 30, 1897, *Hall 758* (UC); Coyote Canyon, Santa Rosa Mts., 5000 ft., June, 1901, *Hall 2137* (UC); eastern base of San Jacinto Mts., June, 1901, *Hall 2110* (UC); Santa Rosa Mts., Santa Rosa, 6500 ft., June 30, 1922, *Munz 5921* (UC; BH); Big Morongo Canyon, San Bernardino Mts., 3000 ft., June 15, 1894, *S. B. Parish 3009* (US; MBG); San Diego Co., 1889, *Orcutt* (US); Laguna Mts., July, 1889, *Orcutt* (US). The following illustrate the form described as *M. viminea:* McCoon's Ranch near Poway, 400–500 ft., June 8–9, 1897, *S. B. Parish 4421* (MBG; GH; US); near San Diego, 1880, *Vasey 491* (US, TYPE of *M. viminea* Greene); San Diego, May, 1906, *T. S. Brandegee* (FM); San Diego, May 21, 1894, *Brandegee* (UC); "along river bed," San Diego Co., ?1878, *Cleveland* (GH). The following illustrate the form known as *M. anemonoides:* Greenhorn Mts., 6000–7000 ft., Kern Co., June 7–15, 1888, *E. Palmer 69* (MBG; US, *type collection* of *M. anemonoides* Greene, TYPE in US); Pah Ute Peak, 5000–6000 ft., June, 1897, *Purpus 5096* (UC; US; GH; MBG); Argus Peak, Kern Co., 5000–6000 ft., June, 1897, *Purpus 5098* (US; UC; GH; MBG); Cottonwood Cr., 7000–7500 ft., Inyo Co., Aug. 1896, *Purpus 1947* (UC); road between Bishop & Andrews Camp, Inyo Co., July, 1913, *K. Brandegee* (UC); Panamint Mts., Wild Rose Canyon, June 24, 1891, *Coville & Funston 2045* (US); Westgard Pass, between Deep Springs Valley and Big Pine, Inyo Co., July 19, 1918, *Ferris 1381* (DH). The following illustrate the form known as *M. oblonga* Greene: Mt. Pinos, 6500 ft., July 7, 1904, *Grinnell* (UC, a good match for the type of *M. oblonga* Greene); Tehachapi Mts., vicinity of Bisses station (?Bissel), June 28, 1895, *Dudley 476* (DH; US; UC); Griffin's, Ventura Co., July, 1902, *Elmer 3952* (GH; US); Frazier Mt., 6000 ft., June 15, 1896, *Dudley & Lamb* (DH; BH); Mt. Pinos,

Ventura Co., North Fork, 6000 ft., June 28, 1905, *Hall 6461* (UC); Kaiser Crest, Fresno Co., 9700 ft., July 28, 1914, *Smiley 646* (GH).

Lower California: Palm Valley, June 3, 1883, *Orcutt 382* (MBG; GH); San Pedro Martir, 7000 ft., May 6, 1893, *T. S. Brandegee* (UC); "Mountains of the Peninsula," July 25, 1885, *Orcutt* (UC); Cantites (?) Mts., July 26, 1883, *Orcutt 927* (GH); mountains of Lower Calif., July 25, 1883, *Orcutt* (FM).

b. Subsp. **stricta** (Parish), comb. nov.

Monardella linoides stricta Parish, Erythea 7: 96, 1899.

M. epilobioides Greene, Pittonia 5: 85. 1902; Abrams, Muhlenbergia 8: 35. 1912; Davidson & Moxley, Fl. South. Calif. 313. 1923.

M. epilobioides var. *erecta* Abrams, Muhlenbergia 8: 36. 1912; Davidson & Moxley, Fl. South. Calif. 313. 1923.

Madronella epilobioides Greene, Leaflets Bot. Obs. 1: 196. 1906.

Herbage similar to that of subsp. *typica* but tending in some to have a short sparse pubescence in addition to the silvery covering; bracts *lanceolate, distinctly short-acuminate, whitish, tinged with rose, to a deep purple,* puberulent or sparingly pubescent, the margin subciliate; calyx puberulent to *sparsely hispid;* the lobes of the corolla tending to lanceolate rather than oblong, the upper lip more often cut to less than half its length.

Specimens examined:

California: The following illustrate the form known as *M. epilobioides* Greene: San Antonio Mts., July, 1896, *Hall* (RMH; BH; US); 12 mi. west of Cajon Pass, Aug. 6, 1896, *Hall 297* (US; UC); the two preceding suggest *M. viminea;* San Bernardino Mts., Aug. 1884, *S. B. Parish 2077* (UC; type of *M. linoides* var. *stricta* Parish); Le Montaine, north of Big Pines, 7300 ft., July 5, 1922, "very abundant on open slopes but hardly in bloom at this time" *Peirson 3160* (J); San Bernardino Mts., Aug. 1881, *S. B. & W. F. Parish 462a* (GH, suggests *M. viminea*); Mill Creek Canyon, 1904, *Smith 105* (UC); Bear Valley, San Bernardino Mts., 6500 ft., June 22, 1894, *S. B. Parish 3008* (UC; MBG; US; *type collection* of *M. epilobioides* Greene, type in US); Little Green Valley, San Bernardino Mts., 7200 ft., July, 1904, *Hall 2* (UC). The following illustrate the form known as *M. epilobioides* var.

erecta Abrams: Mt. San Gorgonio, 7500 ft., July 23, 1904, *Grant 795a* (FM; MBG; UC); Santa Ana R., San Bernardino Mts., 6100 ft., July 27, 1906, *J. & H. W. Grinnell 306* (US); Upper Santa Ana Canyon, 8500 ft., July 26, 1906, *Hall 7578* (RMH; US; BH; MBG; UC); Fish Creek, San Bernardino Mts., 8700 ft., Sept. 1, 1921, *Jaeger* (BH); above Green Valley, July, 1899, *Hall 1362* (UC); on dry ridges, Bear Valley, Aug. 3, 1902, *Abrams 2861* (GH; MBG; UC; BH; US, *type collection* of *M. epilobioides* var. *erecta* Abrams, TYPE in DH); east of Fish Camp, San Bernardino Mts., 6700 ft., July 17, 1921, *Johnston 2898* (BH, suggests *M. australis* Abrams); San Bernardino Mts., 7000 ft., July 19, 1898, *Hall 1021* (UC); South Fork Meadows, Santa Ana Canyon, 8200 ft., Aug. 6, 1906, *Hall 7676* (UC).

NEVADA: Lee Canyon, Charleston Mts., Clark Co., 8000 ft., July 25, 1913, *Heller 10984* (US; MBG; GH).

ARIZONA: Little Meadows, June 28, 1902, *Stephens* (UC).

LOWER CALIFORNIA: Hansens, Sept. 18, 1884, *Orcutt 1224* (GH); San Pedro Martir, 7000 ft., May 6, 1893, *T. S. Brandegee* (UC); San Pedro Martir, Aug. 1903, *Robertson 54* (UC); Oallecitos, San Pedro Martir Mts., 8000 ft., July 15, 1905, *Goldman 1240* (US).

After a careful study of a considerable mass of herbarium material, representing *M. linoides* from most of the localities where it is known to grow, the opinion has been formed that some, at least, of the numerous forms have been caused by hybridization. Whether this is true remains to be determined. In the San Bernardino Mountains, especially, the data are very confusing. One may pass by imperceptible gradations from the form originally described by Dr. Gray as *M. linoides* to the plant of the interior mountains described herein as *M. odoratissima* subsp. *glauca*. In a similar way he may pass into *M. odoratissima* subsp. *australis* or into the group described as subsp. *stricta*. Until some evidence is forthcoming as to the nature of these variants, whether partly or wholly environmental, whether hybrid, due to the existence of several closely related subspecies, or both, it seems desirable to retain the present arrangement which will permit of fairly close determination of material. Furthermore, the two groups as thus outlined have a distribution which seems fairly consistent.

M. viminea Greene is a plant in which the stems are unusually long, with long internodes, the leaves similarly elongate and glabrate, and the calyx and bracts pubescent. In shape and size the bracts are midway between subsp. *eulinoides* and subsp. *stricta*. As it is found on the type sheet, the several stems have been coiled, in order to gain space, the whole suggesting the willowy aspect from which the name was derived. Few collections may be referred to this, and the author has seen no plants as extreme as the plant of the type sheet.

Only a photograph of the type sheet of *M. oblonga* Greene has been available for study. However, the collection of Grinnell on Mt. Pinos (UC, 149541) is a very good match for both the description and photograph; the type was collected "in the mountains south of Tehachapi," June 24, 1889, by Greene and is at Notre Dame. In general, the more hairy calyx and broader leaf characterize the plants of the more northern stations.

M. anemonoides Greene is an extreme form in which the bracts are unusually developed in such a way as to envelop and conceal the flowers. The bracts of the plant collected at the same time and deposited at the Missouri Botanical Garden (the type is in the U. S. National Herbarium) are not greatly above normal, and apart from this collection the author has seen nothing to equal the type sheet.

M. linoides subsp. *stricta* may, in a general way, be divided into two forms, namely, one (*M. epilobioides* Greene) with but two or three slender, erect, fertile branches (suggestive of *M. viminea* Greene) which arise from a low tuft of sterile branches, with elliptic-oblong leaves, and a second form (*M. epilobioides* var. *erecta* Abrams) in which the fertile branches are numerous, subequal, and more or less fastigiate, with leaves shorter and linear-oblong.

§ Section IV. Annuae

12. M. undulata Benth. Lab. Gen. et Sp. 332. 1834; in DC. Prodr. **12:** 190. 1848; Gray, Proc. Am. Acad. **11:** 102. 1876; Bot. Calif. **1:** 594. 1876; Syn. Fl. N. Am., ed. 2, **2**[1]**:** 358. 1886; Jepson, Fl. West. Middle Calif., ed. 2, 363. 1911.

Madronella undulata Greene, Leaflets Bot. Obs. **1:** 168. 1906.

Annual or perennial, usually forming a *bush-like plant* 20–40 cm. tall, or erect, rather slender, the ascending branches unbranched, branches purple, puberulent; leaves somewhat *succulent, oblanceolate-oblong,* 2–5 cm. long, obtuse, glabrate, thinly villous, or shortly pubescent, the margins undulate or crisped, narrowed to a short petiole; glomerules compact, 2.5–3.5 cm. broad, bracts broadly ovate or orbicular to elliptical, obtuse or acute, variable in size, equal to the calyces or much exceeding the flowers, submembranous with green or purple prominent parallel veins, or scarious, glabrate to villous; calyx 5–9 mm. long, variable on the same plant, 13–15-veined, tapering downwards, subglabrous and subscarious below, green or purplish and villous above, or villous throughout, the teeth ovate-triangular, obtuse, hairy, white within; corolla rose-purple, 14–20 mm. long, the tube twice the length of the corolla or less, the *throat ample and hairy within,* the upper lip somewhat shorter, the lobes coalesced two-thirds its length or more, those of the lower coalesced one-third to one-fourth its length, linear-oblong or tapering; anthers divergent, the connective equilateral, well developed.

California: Gigling, Monterey Co., June 1903, *Elmer 4379* (OAC); along the railroad 2 mi. northeast of Del Monte, Monterey Co., July 31, 1906, *Heller 8426* (GH; US; MBG); Point Reyes, Marin Co., July, 1903, *Elmer 4611* (MBG; US); Point Reyes, May 5, 1901, *Eastwood* (GH); Point Reyes, June 23, 1915, *Eastwood 4773* (GH); San Francisco, 1865, *Bolander* (MBG; GH); San Franciscò, near Lake Merced, August 5, 1913, *Suksdorf 786* (GH); "California," *Hartweg* (GH); Bardins, June, 1903, *Elmer 4379* (US; MBG); "Northern California," *D. Douglas* (GH; a portion of the *type collection* cited by Bentham); Lake Merced near San Francisco, June, 1905, *K. Brandegee* (RMH); Clarke Creek, 10 mi. from San Luis Obispo, June 26, 1876, *E. Palmer 362* (GH; MBG; US); Arroyo Grande, San Luis Obispo Co., June, 1887, *Lemmon 4622* (GH); sea-shore hills, Feb. 3, 1882, *Summers* (MBG; US); Nipomo, San Luis Obispo Co., sandbanks, *Bolander* (GH); Nipomo, San Luis Obispo Co., Apr. 11, 1861, *Brewer 421* (US); Castroville, Monterey Co., *K. Brandegee* (US).

Var. **crispa** (Elmer), comb. nov.

Monardella crispa Elmer, Bot. Gaz. **39:** 46. 1905.

A *low shrubby plant* 20–30 cm. tall, bush-like in appearance, the branches simple or branching, *lanately villous*, the older parts covered with a light brown checking bark; leaves oblanceolate-oblong, 2–5 cm. long, as much as 1 cm. broad, very blunt at the apex, rather succulent, pubescent, undulate or crisped, narrowed into a short petiole; bracts ovate or roundish, villous; calyx 6–8 mm. long; corolla 12–14 mm. long, the lobes tapering and tending to lanceolate rather than oblong.

Specimens examined:

CALIFORNIA: Surf, Santa Barbara Co., May, 1902, *Elmer 3965* (MBG; US; *type collection* of *M. crispa* Elmer, TYPE in DH); Santa Maria, Santa Barbara Co., 1882, *Jared* (GH); Surf, Santa Barbara Co., "on beaches but most abundant on the hills," May, 1909, *K. Brandegee* (UC; GH; US); no locality stated, *Coulter 536* (GH; cited by Bentham); San Luis Obispo, *Summers* (GH); Point Reyes, May, 1906, *Eastwood* (US); Casmalia, Santa Barbara Co., *Eastwood* (US).

13. M. Douglasii Benth. Lab. Gen. et Sp. 332. 1834; in DC. Prodr. **12**: 190. 1848; Gray, Proc. Am. Acad. **11**: 102. 1876; Bot. Calif. **1**: 595. 1876; Syn. Fl. N. Am., ed. 2, **2**[1]: 357. 1886; Jepson, Fl. West. Middle Calif., ed. 2, 363. 1911.

Monardella candicans var. *venosa* Torrey, Pacif. R. R. Rept. **4**: 123. 1857 (Whipple's Exp.).

Madronella Douglasii Greene, Leaflets Bot. Obs. **1**: 168. 1906.

Annual, erect, with divaricate branches, 20–30 cm. tall, or often simple, with a single terminal inflorescence; stems purplish, puberulent; leaves 1–3 cm. long, lanceolate to linear-oblong, puberulent, narrowed at the base to a petiole 1–5 mm. long; glomerules 1.5–3 cm. broad; bracts ovate-lanceolate, surpassing the calyces, *with a strong midrib and a well-defined marginal vein formed by the confluence of the ascending lateral veins, the intravenous tissue like isinglass when dry, transparent, the veins purple, rough-pubescent, margin ciliate;* calyx 7–9 mm. long, 15-nerved, pubescent or hirsute, the teeth rigid, acute, subcuspidate, pubescent within; corolla deep reddish purple, 11–12 mm. long, the tube somewhat exserted, retrorsely puberulent, lips subequal, the lobes of the upper coalesced more than half its length, those of the lower nearly

free, slender, tapering slightly; the anther-sacs subparallel, confluent behind, the connective scarcely wider than the filament.

Specimens examined:

California: Moragua Valley (Bay Region), Aug. 1863, *Bolander 2499* (GH; UC; US); plains of the Feather River near Marysville, May 25, 1854, *Bigelow* (Whipple's Exp.) (GH; US; *type collection* of *M. candicans* var. *venosa* Torrey); Oakland, May 29, 1892, *Brandegee* (GH); Gilroy, June 16, 1896, *Jepson* (US; MBG; J); Mt. Diablo, July, 1903, *Elmer 4544* (MBG); Plumas Co., *Austin* (MBG); Oakland Hills, 1865, *Bolander* (GH; MBG); near San Francisco, *Kellogg* (GH); Mt. Hamilton, July, 1905, *R. I. Smith* (RMH); Cherokee, Butte Co., May, 1879, *Bidwell* (GH); Alameda, 1876, *Vasey* (GH); Butte Co., 1882, *Parry* (UC); Chico Valley, May, 1882, *Parry* (UC); Black Canyon (? Marin Co.), July, 1885, *K. Brandegee* (UC); San Jose, May 20, 1897, *Chipman* (US); locality not given, 1875, *Vasey* (US).

14. M. lanceolata Gray, Proc. Am. Acad. **11**: 102. 1876; Bot. Calif. **1**: 594. 1876; Syn. Fl. N. Am., ed. 2, **2**[1]: 357. 1886; Hall, Univ. Calif. Publ. Bot. **1**: 108. 1902; Jepson, Fl. West. Middle Calif., ed. 2, 363. 1911; Abrams, Muhlenbergia **8**: 41. 1912; Fl. Los Angeles, ed. 2, 318. 1917; Davidson & Moxley, Fl. South. Calif. 314. 1923.

Monardella sanguinea Greene, Pittonia **5**: 86. 1902.

M. acuta Greene, in Herb. Baker. 1193. 1902.

Madronella sanguinea Greene, Leaflets Bot. Obs. **1**: 169. 1906.

Madronella lanceolata Greene, Leaflets Bot. Obs. **1**: 169. 1906.

Annual, erect, 30–50 cm. tall, branching throughout, but with a tendency to branch chiefly in the upper axils, the branches divaricate but curving upwards, puberulent, purplish; leaves lanceolate, 3–4 cm. long, obtuse, entire, sparsely puberulent, narrowed to a slender petiole 0.5–1.5 cm. long; glomerules 1.5–3 cm. broad, *bracts ovate-lanceolate, acute*, surpassing the calyces, scabrous, membranous but *green, pinnately veined with numerous readily observed net-like secondary veins, the principal veins prominent, often costate;* calyx 6–8 mm. long, glabrous or scabrous, sometimes bristly at the sinuses, veins slender, typically 13, teeth ovate-triangular, acute, hirsute within; corolla rose-purple, 12–15 mm.

long, the tube somewhat exserted, puberulent, the limb 3–5 mm. long, the upper lip shorter, lanceolate in outline, the lobes coalesced one-half its length or more, those of the lower lip free nearly or quite to the base, tapering slightly; anther-sacs divergent at an angle of about 60°, the connective about as wide as the filament, little developed and scarcely evident from behind; nutlets oblong-oval, about 2 mm. long.

Specimens examined:

CALIFORNIA: Tallac, Lake Tahoe, 6300 ft., July 18, 1913, *Smiley 132* (GH); Tioga road above Aspen Valley, 6500 ft., Aug. 24, 1916, *Smiley* (GH); Yosemite Valley, Sept.–Oct. 1878, *Phillips & Sargent* (GH); Glendora, July 7, 1902, *Abrams 2662* (GH; MBG); Cuyamaca, 4000 ft., June 30, 1917, *Spencer 635* (GH); Cajon Pass, June 8, 1861, *Cooper* (GH; US); Shasta Co., between the McCloud and Sacramento Rivers, July 23, 1916, *Heller 12499* (GH; MBG); Oakgrove Canyon, Liebre Mts., 3500–4000 ft., July 19–21, 1908, *Abrams & McGregor 350* (GH); Bloomington, June 2, 1917, *S. B. Parish 11268* (GH; BH; MBG); Colton, April, 1885, *S. B. Parish 1750* (GH); locality and date not given, *Bridges 308* (GH); Fort Tejon, 1857–58, *de Vasey 77* (GH); south fork, Kaweah River, Tulare Co., July 20, 1904, *Culbertson* (Baker 4489) (GH; MBG); Nevada City, July 14, 1905, *Heller 8114* (GH); no locality given, 1872, *Gray* (GH); San Diego, 1875, *Cleveland* (GH; some of these approach var. *microcephala*); Ramona Valley, San Diego Co., June 19, 1903, *Abrams 3773* (GH; MBG); Yosemite Valley, July, 1866, *Bolander 6320* (GH; US); Calaveras Co., 1877, *Hooker & Gray* (GH); foothills of the Sierra Nevada, 1865, *Torrey* (GH); Ojai Valley, July, 1875, *Rothrock 175* (GH); Snowdon Ranch, Calaveras Co., July–Aug., 1890, *Jepson 50f* (J); Hetch-Hetchy, "opens" on valley floor, *Jepson 3437* (J); Augustine's ranch, Palómar, May 30, 1901, *Jepson 1549* (J); Mineral King road, 5900 ft., Aug. 1–12, 1900, *Jepson 1160* (J); Colton, June, 1882, *S. B. & W. F. Parish 1430* (GH); southern California, 1876, *Parry & Lemmon 331* (GH; MBG); Tulare Mts., May, 1878, *Lemmon 336* (GH); Middle Tule River, 3000–4000 ft., April–Sept. 1897, *Purpus 5040* (GH; MBG); Middle Tule River, 4000–5000 ft., April–Sept. 1897, *Purpus 5050* (GH; MBG); Newcastle Road, Plumas Co., May, 1894, *Ames*

(GH); Yosemite Valley, June 28, 1911, 4000–5000 ft., *Abrams 4562* (GH); Pitt to Baird, Shasta Co., July 25, 1912, *Eastwood 1439* (GH; MBG); West Point Bridge, 2300 ft., July 7, 1896, *Hansen 1824* (MBG); Mariposa, June 14, 1903, *Congdon* (MBG); Nevada Co., July 14, 1905, *Heller 8114* (MBG); Ranger Station, Amador Co., 2000 ft., June, 1891, *Hansen 128* (MBG); mountains above Claremont, no date, *Davis* (MBG); Mojave River, June 1, 1876, *E. Palmer 363* (MBG); Sierra Santa Monica, June, 1889, *Hasse* (MBG); Mt. Lowe, Los Angeles Co., 1903, *Grant 796a* (MBG); Strawberry Valley, San Jacinto Mts., 6000 ft., Aug. 28, 1896, *Hall 340* (MBG); southern California, near the boundary, June, 1880, *S. B. Parish* (MBG); San Bernardino Mts., 3000 ft., June 29, 1888, *S. B. Parish* (MBG; it is probably this collection which was referred by Greene to *M. sanguinea*); Tigh's ranch, San Diego Co., July 4, 1875, *E. Palmer 294* (MBG); North Fork and vicinity, May 30–June 8, 1903, *Griffiths 4628* (MBG); Madera, July 10, 1904, *Griffiths 6589* (MBG); Tehachapi Peak, June 28, 1895, *Dudley 348* (OAC); Nevada (?City), no date, *Pratten* (MBG); La Crescenta, 1897, *Wislizenus 1307* (MBG); Dry Canyon, July 15, 1917, *Johnston 1912* (BH); Palomar, July, 1901, *Schellenger* (BH); Strawberry Valley, San Jacinto Mts., 5200–6000 ft., July, 1901, *Hall 2527* (BH); Santa Ana River, San Bernardino Mts., 6300 ft., Aug. 21, 1922, *Munz 6149* (BH); Little Chico Cr., 2000 ft., July 5, 1900, *Leiberg 5022* (US); Deer Cr. Canyon, Tehama Co., July 17, 1911, *Eggleston 7277* (US); Breckinridge Range, Kern Co., 5000 ft., 1905, *Hopkins* (US); between Temecula and Pala, July 10, 1915, *Collins & Kempton 224* (US); San Jacinto Plains, 1880, *Vasey 490* (US); Tehachapi Pass, Kern Co., June 25, 1891, *Coville & Funston 1113* (US); Lyttle Cr., San Gabriel Reserve, 1800 m., April 29, 1898, *Leiberg 3364* (US); Tejunga Wash, Los Angeles Co., July 6, 1905, *Grinnell* (US); Yosemite Valley, Aug. 17, 1872, *Redfield 6497* (MBG); Yosemite Valley, 1886, *Bolander 6320* (MBG); Forest Ranch, Butte Co., July 24, 1914, *Heller 11628* (GH; OAC; US); Azusa, June 22, 1915, *Macbride & Payson 731* (GH); Plumas Co., *Ames* (GH); San Bernardino Mts., *S. B. & W. F. Parish 405* (MBG); Palomar Mt., San Diego Co., Sept. 14, 1922, *Spencer 635* (BH); Etiwanda, June 16, 1921,

1500 ft., *Munz 4658* (BH); San Dimas Canyon, July 4, 1915, *Davis* (BH); San Jacinto, 6000 ft., July 15, 1898, *Anthony* (UC); Little Bear Valley, San Bernardino Mts., 5000 ft., July 31, 1897, *Chandler* (UC); head of Hemet Valley, 5000 ft., July 3, 1922, *Munz* (UC); Julian, Aug. 4, 1892, *Dunn* (UC); Downieville, Sierra Co., 1909, *Kennedy 29* (UC); El Dorado Co., Aug. 1914, *K. Brandegee* (UC); Rennies Sta., 3000 ft., June 27, 1897, *Reed* (BH); San Joaquin Hills, Orange Co., July 13, 1901, *Abrams 1788* (BH); Fort Tejon, June, 1881, *S. B. Parish* (J); Fish Cañon, San Gabriel Mts., 1000 ft., July 1, 1919, *Peirson 511* (J).

Nevada: Lake Tahoe, 6300 ft., Washoe Co., Aug. 8, 1906, *Kennedy 1459* (MBG); Kings Canyon, Ormsby Co., 1700–2000 m., June 30, 1902, *Baker 1193* (GH; MBG; US); western Douglas Co., 6250 ft., *Hall & Chandler 4593* (UC; US).

Arizona: Mont Cr. (northern Ariz.), Aug. 9, 1894, *Wilson* (UC, as "*M. lanceolata Arizonica*").

As it occurs in the southern part of its range, *M. lanceolata* tends to become more slender, lower in height, with fewer branches, these being in the upper axils and divaricate. The glomerules are often reduced in size and the corollas are a deeper color. It was such a plant as this which was described by Greene as *M. sanguinea.* The author has been unable to find any differences which might not be ascribed to the differing conditions of its habitat. *M. acuta* Greene is a depauperate, unbranched form bearing a single terminal glomerule, which is in all respects that of *M. lanceolata.*

Typical *M. lanceolata* var. *microcephala* occurs only in the extreme southern portion of the specific range. The author has seen only one or two collections, even from the type locality, which equal the type collection in the extreme reduction in the size of the glomerules. All gradations occur, and it is a matter of opinion as to where the line may be drawn between the variety and the more typical plant. The writer has not seen the Orcutt collection which formed the basis for *M. peninsularis,* but from a comparison of the Orcutt material from the same locality with Greene's description, he feels certain that such a plant was represented, and that *M. peninsularis* is synonymous with the variety *microcephala.* In describing var. *microcephala* Abrams

differentiated between it and the typical plant, among other things, by the absence of hispid hairs at the sinuses of the calyx. Johnston in describing var. *glandulifera* notes a point of difference between his plant and var. *microcephala* in that the hispid hairs are present. Careful examination shows that these hispid hairs about the base of the calyx teeth may be variously developed in different collections of the typical plant and the variety, and that while some sinuses may be naked, the calyx is rarely wholly so. This is true of the type collection of *M. lanceolata* var. *microcephala* and of the Orcutt collections. Furthermore, the stalked glands upon which the var. *glandulifera* was based may be found occasionally in both the typical plant and the variety *microcephala*, more especially in the southern forms, although no plants were observed in which they were as abundant as in the Johnston collection. It accordingly seemed preferable to consider Mr. Johnston's plant as a form of var. *microcephala.* A great diversity may be observed in the size of the glomerules upon a single plant, either of the variety or the more typical specimens, especially in the southern part of the range, such that it would appear that while environmental conditions had been favorable for the normal development of some of the glomerules others had been stunted or even aborted. At the same time vigorous plants with well-developed foliage usually have the glomerules of about the same size.

The foliage varies considerably, and robust, rankly growing plants may have quite a different aspect from those subjected to drier less favorable conditions. This variation in the leaf form is paralleled by an unusual development of the outermost bracts, or the involucral pair of leaves, which in some plants reach a length of several centimeters and thus form a reflexed foliaceous involucre. All gradations may be observed. Such a plant (N. C. Wilson, Mont Cr., Ariz., UC, 25461) has been named in the herbarium by some one "*M. lanceolata Arizonica.*" It is not peculiar to Arizona, however, but extends throughout most of the specific range, occurring in Butte Co., the Yosemite, the San Bernardino Mountains, and San Diego Co. It is considered to be only an environmental form.

One plant of Heller's collection, No. 12499 (OAC, 8932), while

similar in all other respects to *M. lanceolata*, bore reduced corollas, with very small stamens. Since apparently normal (but smaller) seeds were produced, it will be of interest to note whether this variant has established itself. No other similar plant was found among the numerous collections of *M. lanceolata.*

Var. **microcephala** Gray, Syn. Fl. N. Am., ed. 2, 2^1: 459. 1886; Abrams, Muhlenbergia **8**: 42. 1912; Davidson & Moxley, Fl. South. Calif. 314. 1923.

Monardella peninsularis Greene, Pittonia **5**: 87. 1902.

M. lanceolata var. *glandulifera* Johnston, Bull. South. Calif. Acad. Sci. **18**: 20. 1919.

Madronella peninsularis Greene, Leaflets Bot. Obs. **1**: 169. 1906.

A form with the glomerules reduced in size to 1 cm. or less broad, the bracts and flower parts being reduced accordingly. The stems and branches are more slender and divaricately branched. All gradations seem to occur.

M. peninsularis Greene is based upon a collection made by Orcutt, June 6, 1885, in northern Lower California.

Specimens examined:

California: Potrero, July 24, 1883, *Orcutt 928* (GH, type; MBG); El Campo, dry valley, Aug. 14, 1917, *Munz 1681* (BH); Cameron's Ranch, Laguna, June 22, 1894, *Schoenefeld 3692* (US); Pine Valley, Aug. 12, 1894, *Mearns 3983* (US); near San Diego, 1875, *E. Palmer 257* (US); San Diego Co., April, 1890, *Orcutt* (MBG); Pine Valley, San Diego Co., *Orcutt* (MBG); mountains of San Diego Co., Aug. 1879, *Orcutt 57* (GH); Brown's Flats, San Antonio Mts., 4300 ft., Sept. 1, 1918, *Johnston 2139* (UC; BH, 4040; *type collection* of var. *glandulifera* Johnston, type in BH); ?Fish Creek, San Bernardino Mts., 6500 ft., July 10, 1906, *Grinnell 261* (US).

Lower California: Hansen's, July 30, 1883, *Orcutt 929* (GH); La Gralla, San Pedro Martir, 7000 ft., July 20, 1905, *Goldman 1255* (US).

15. M. Breweri Gray, Proc. Am. Acad. **7**: 386. 1867, and **11**: 102. 1876; Bot. Calif. **1**: 594. 1876; Syn. Fl. N. Am., ed. 2, 2^1: 357. 1886; Jepson, Fl. West. Middle Calif., ed. 2, 363. 1911.

Monardella Elmeri Abrams, Muhlenbergia 8: 43. 1912; Fl. Los Angeles, ed. 2, 318. 1917; Davidson & Moxley, Fl. South. Calif. 314. 1923.

Madronella Breweri Greene, Leaflets Bot. Obs. 1: 168. 1906.

Annual, erect, 15–65 cm. tall, branching throughout, the branches ascending, the lowermost longest, sometimes nearly equal to the main stem, rebranching, cinereous-puberulent above; leaves ovate-lanceolate or oblong, 1.5–3.5 cm. long, tapering at both ends, obtuse to slightly acuminate, puberulent, petioles 2–10 mm. long; glomerules 2–3 cm. in diameter, bracts *broadly ovate,* little exceeding the calyces, *abruptly acuminate to a cusp-like point, the veins 5–9, arising from the base, subparallel and converging at the tip, the midvein stronger and branching below,* the outermost bracts pinnately veined throughout, all *thinly pubescent or scabrous* on the veins; calyx 6–8 mm. long, 14–15-nerved, scarious below, the teeth acute, slender, unequal, hirsute within; corolla 12–14 mm. in length, rose-color, the tube retrorsely puberulent, the limb about 5 mm. long, the lips subequal, the lobes of the upper lip coalesced about two-thirds of the length of the lip or more, those of the lower lip coalesced almost one-third its length, tapering somewhat, obtuse, the anther-sacs subparallel, confluent behind above the connective, but little broader than the filament; nutlets oblong-oval, 1.5–1.8 mm. long, grayish brown and mottled.

Specimens examined:

California: Monterey Co., Nacimiento River, Sept. 19, 1894, *Eastwood* (GH); Santa Lucia Mts. (received at GH, July 22, 1898) *Eastwood* (GH, fragment); Lemmon's ranch, Cholame, June, 1887, *Lemmon 4548* (GH); Acton, June, 1902, *Elmer 3681* (GH; MBG; FM; *type collection* of *M. Elmeri* Abrams, type in DH); Corral Hollow, Contra Costa Co., east side of north Coast Range, east of Mt. Diablo, June 3, 1862, *Brewer 1213* (GH, type; UC; US); edge of Antelope Valley near Neenach, June 6, 1896, *Dudley & Lamb 4341* (DH); Hernandez, San Benito Co., June 13, 1903, *Lathrop* (DH); 3 mi. above Acton on Palmdale-Saugus Road, June 12, 1918, *Ferris 949* (DH); Sprague's, Liebre Mts., Los Angeles Co., June 8, 1896, *Dudley & Lamb 4341* (BH); Lockwood Creek canyon, Mt. Pinos region, Ventura Co., June 24,

1896, *Dudley & Lamb 4668* (BH); San Antonio River, July, 1880, *Vasey 493* (US); San Miguelito Ranch, Santa Lucia Mts., June 14–20, 1901, *Jepson 1647* (J); near Templeton, July 20, 1913, *Abrams 5048* (DH).

While a well-marked species of fairly wide distribution, it has been little understood and often confused with *M. lanceolata*. Beyond the purplish, somewhat more scarious bracts of the Elmer and similar collections, I can see no essential difference between *M. Breweri* and *M. Elmeri*, certainly none sufficient to warrant specific distinction. The species may be readily distinguished from *M. lanceolata* by the more scarious acuminate bracts.

There are numerous "Corrals" and numerous "Hollows" throughout the state. "Corral Hollow," however, is near Tesla in Alameda County at an elevation of 1000–2000 ft. on the interior side of the coast range.

16. M. Pringlei Gray, Proc. Am. Acad. **19:** 96. 1883; Syn. Fl. N. Am., ed. 2, **2**[1]: 459. 1886 (suppl.); Abrams, Muhlenbergia **8:** 42. 1912; Fl. Los Angeles, ed. 2, 318. 1917; Davidson & Moxley, Fl. South. Calif. 314. 1923.

Madronella Pringlei Greene, Leaflets Bot. Obs. **1:** 169. 1906.

Annual, erect, 15–40 cm. tall, cinereous-puberulent throughout, occasionally shortly villous near the inflorescence, branching throughout, the branches ascending, the lowermost longest, sometimes nearly equal to the main stem, rebranching; leaves ovate-lanceolate or oblong, 1.5–3.5 cm. long, tapering at both ends, obtuse or slightly acuminate, pubescent, petioles 2–10 mm. long; glomerules 2–2.5 cm. broad, bracts *ovate,* little exceeding the calyces or equal to them, *abruptly acuminate, veins 5–7, arising from the base, subparallel and converging at the point, the midvein stronger and branching below, the outmost bracts pinnately veined, villous with fine trichomes;* calyx 6–7 mm. long, 14–15-nerved, scarious below, pubescent, villous above, the teeth nearly equal, slender, acute, hirsute within; corolla 11–13 mm. long, rose-color, the tube puberulent, the limb 3.5–4 mm. long, the lobes of the upper lip coalesced two-thirds its length or more, those of the lower coalesced about a third its length, tapering, stamens exceeding the lips slightly, the anther-sacs divergent at

an angle of about 90°, distinct, the connective about three times the width of the filament, the margin entire; nutlets oblong-oval, 1.2–1.5 mm. long, grayish brown and more or less mottled.

Specimens examined:

CALIFORNIA: Colton, May, 1887, *S. B. Parish 1881* (MBG); locality not stated, 1881, *Parry* (GH); Colton, May 23, 1882, *Pringle* (MBG; US; GH; TYPE); Colton, June 20, 1905, *S. B. Parish 5398* (GH); vicinity of San Bernardino, May 14, 1895, *S. B. Parish 3653* (GH; MBG; US); sandhills near Colton, June 20, 1907, *S. B. Parish 6396* (DH); Declez Pass, Jarupa Hills, June 20, 1904, *Wilder 199* (BH).

The relationship between *M. Breweri* and *M. Pringlei* is very close, and while some forms of one approach forms of the other, yet one may definitely and readily place them in one category or the other. The corolla of *M. Pringlei* is constantly smaller and of a different texture. The anthers, while similar, nevertheless show small points of difference, namely, a greater development of the connective, which is in general broader than *M. Breweri*, appearing more translucent, with the margin distinctly convex; in the rear, above the connective, the anther-sacs appear nearly or quite distinct. In addition to these rather obscure points, the nature of the bract, its smaller size, different texture, and woolly covering afford a ready means of distinction. While of similar aspect the entire plant is more slender and of less robust habit than *M. Breweri*. In some collections there is a suggestion of a scarious margin at the tip of the calyx teeth, the midrib being prolonged slightly.

17. M. candicans Benth. Pl. Hartweg. 330. 1839; Gray, Trans. Am. Acad. **11**: 102. 1876; Bot. Calif. **1**: 594. 1876; Syn. Fl. N. Am., ed. 2, **2**¹: 358. 1886; Jepson, Fl. West. Middle Calif., ed. 2, 363. 1911.

Madronella candicans Greene, Leaflets Bot. Obs. **1**: 168. 1906.

Annual, erect, 30–40 cm. tall, *branching from the upper nodes, forming a corymbose group of inflorescences;* branches seldom rebranching, purplish, puberulent; leaves lanceolate to oblong-lanceolate, 2–4 cm. long, obtuse, entire, puberulent or nearly glabrous, narrowed to a slender petiole 0.3–1 cm. long; glomerules

1.5–2.5 cm. broad, subglobose, bracts broadly *ovate, obtuse, scarious, the veins subparallel and green, the secondary veins net-like, evident, pubescent or puberulent, the margin villous-ciliate;* calyx 5–5.6 mm. long, scarious in the lower half, *13-nerved,* subglabrous below, villous above, teeth subequal, obtuse, the margin narrowly scarious and terminating in an *acute white scarious tip, but not cuspidate,* villous inside and out; corolla white, purple-dotted in some, 10–11 mm. long, the tube but little exserted, retrorsely puberulent, the limb 4–5 cm. long, the upper lip shorter, the lobes coalesced for more than half the length of the lip, those of the lower lip coalesced only at the base, the lobes of both rather broad, tapering, anthers oblong in outline, divergent at an angle of about 90°, quite distinct, the connective about three times the width of the filament, the margin notched; nutlets about 1.5 mm. long, mottled.

Specimens examined:

California: Auburn, Plumas Co., 1894, *Ames* (GH); no locality given, 1845–47, *Fremont's Exp.* (GH); Consumnes River, 1866, *Rattan 222* (US; GH); Yosemite, June 15, 1891, *Fritchey 80* (MBG); Fresno Creek, Madera Co., June, 1915, *Hall 10043* (GH; US; MBG; a very good match for the type); North Fork, May 30–June 8, 1903, *Griffiths 4619* (US; MBG); Volcano, Amador Co., June 25, 1896, *Hansen 1759* (MBG; US); Tollhouse, Fresno Co., June 13, 1900, *Hall & Chandler 26* (MBG; US); Colfax, July 4, 1882, *Jones 3458* (MBG; US); "Mt. Sacramento" (mountains of Sacramento River), no date, *Hartweg* (GH; labeled in Dr. Gray's handwriting "Pl. Hartweg. no. 1911," *type collection* from Herb. Benth.); Knight's Ferry, Stanislaus Co., May 7, 1854, *Bigelow,* Whipple's Exp. (GH); Calaveras Co., May 18–30, 1895, *Davy 1334* (UC); Greenhorn Range, Kern Co., June 2–10, 1904, *Hall & Babcock 5005* (US; UC); Eldorado Co., Sweetwater Cr., June 2, 1908, *K. Brandegee* (UC); no locality, *Bridges 308* (US); Coloma, Eldorado Co., June 23–24, 1892, *E. Palmer 2373* (US); Mariposa Co., June 15, 1892, *Congdon* (US).

18. M. exilis (Gray) Greene, Pittonia **5**: 86. 1902; Abrams, Muhlenbergia **8**: 43. 1912; Davidson & Moxley, Fl. South. Calif. 314. 1923.

Monardella candicans var. *exilis* Gray, Syn. Fl. N. Am., ed. 2, 2[1]: 358. 1886; Bot. Calif. 2: 476. 1880.

Madronella exilis Greene, Leaflets Bot. Obs. 1: 169. 1906.

Annual, erect, 10–30 cm. tall, cinereous-puberulent, brownish-purple, branching throughout, the branches flexuous, the lowermost longest, nearly equalling the main stem in some, rebranching; leaves oblanceolate to oblong, 1.5–2.5 cm. long, obtuse, narrowed to a slender short petiole or sessile, puberulent; glomerules 1.5–2.5 cm. broad, bracts *ovate*, usually surpassing the calyces, *scarious, but with green subparallel veins, with few or no secondary veins, the margin white-scarious, terminating in a short scarious abrupt acumination, the margin and back short-pubescent, the entire bract a bright purple in some;* calyx 5–5.5 mm. long, *15-nerved*, scarious in the lower half, sparingly pubescent, the teeth subequal with a *white-scarious margin and tip bristly without, hirsute within;* corolla white, 10 mm. long at most, the tube barely exserted, retrorsely pubescent, the limb 2.5–3 mm. long, the upper lip shorter, the lobes coalesced for more than half its length, those of the lower lip one-third to one-half its length, lanceolate, obtuse; stamens shortly exserted, the anther-sacs divergent at an angle of about 60°, the connective about twice the width of the filament, its margin entire.

Specimens examined:

California: Lancaster, May, 1909, *K. Brandegee* (UC); Palmdale, June, 1902, *Elmer 3648* (US; GH; MBG); Mojave River, June, 1886, *S. B. Parish 898c* (MBG; US); Walker Pass, Apr.–Sept. 1897, *Purpus 5347* (MBG; US); north fork Kern River, June 7–15, 1888, *E. Palmer 126* (GH; US; it was upon the sheets of this collection at the National Herbarium that *M. exilis* Greene was based); Mojave Desert, about 4000 ft., June 14, 1895, *S. B. Parish 3734* (GH; US); Mojave River, 1876, *E. Palmer 364* (US; GH; *type collection* of *M. candicans* var. *exilis* Gray, type at GH, a fragment at DH); Mojave Station, June 10, 1906, *Hall & Chandler 7382* (US; RMH; BH; UC); Rabbit Springs, 3000 ft., Apr. 29, 1906, *Hall & Chandler 6772* (UC); Mojave River, near Hesperia, May 31, 1892, *S. B. Parish 2450* (UC); Mojave River, Burcham's ranch, May 29, 1901, *S. B. Parish 4909* (DH); vacant lot, Lancaster, Los Angeles Co., *Ferris*

925 (DH); Lancaster, June 4, 1896, *Dudley & Lamb 4302* (BH); Victorville, spring of 1917, *Edwards* (BH); Little Rock Creek, sand flat, 3400 ft., *Peirson 2416* (BH; J); mouth of Deep Creek, Mojave Desert, May 19, 1921, *Jaeger 1155* (BH); Mojave Desert, May 17, 1882, *Pringle* (US).

While *M. exilis* resembles *M. candicans* in many ways, the author is of the opinion that the relationships between *M. candicans*, *M. leucocephala* and *M. exilis*, together with their relation to the other annual species is better shown by its retention as a species, rather than a subspecies or variety of *M. candicans*. It may be distinguished from the latter by the habit of branching, the smaller corolla and less exserted tube, the number of calyx veins, and more especially by the nature of the bract, which, despite the similarity, holds certain differences. These differences, when learned, permit it to be readily recognized, so that one may quickly separate a number of specimens, as they appear dried, by observation of the bract alone, due perhaps to the more opaque nature of the tissue, the greater crowding of the veins, the fewer and less conspicuous secondary veins, and the white-scarious margin and acuminate tip.

19. M. leucocephala Gray, Proc. Am. Acad. **7:** 385. 1867; ibid. **11:** 102. 1876; Bot. Calif. **1:** 595. 1876; Syn. Fl. N. Am., ed. 2, **2**[1]: 358. 1886; Jepson, Fl. West. Middle Calif., ed. 2, 363. 1911.

Madronella leucocephala Greene, Leaflets Bot. Obs. **1:** 169. 1906.

Annual, erect, 15–20 cm. tall, cinereous-puberulent, branching throughout, the branches regularly dichotomous, ascending, the lowermost longest; leaves lanceolate or oblong-lanceolate, obovate in one specimen, 1–1.5 cm. long, pubescent, the veins scarcely evident, on petioles 2–3 mm. long; glomerules 1.5 cm. in diameter, subcorymbose, bracts *ovate, orbicular or obovate*, with a short acumination, *scarious, pure white*, the veins parallel from the base but not prominent, the cross veins few; calyx 5–6 mm. long, tapering downwards, *15-nerved*, hirsute above, the teeth *white, attenuate into a spreading and recurved white cusp;* corolla white, 5–5.5 mm. long, *nearly included within the calyx*, the upper lip

shorter, incised less than half its length, the lower lip incised about two-thirds its length, the lobes lanceolate, acute, the middle lobe of the lower lip somewhat larger than the lateral lobes; stamens included, *those of the upper lip appearing sessile,* the anthers subsagittate, the anther-sacs subparallel, the connective wider than the filament, indented; nutlets oblong-oval, tapering toward the base, 2 mm. long, apparently only one maturing.

Specimens examined:

CALIFORNIA: plains near Merced "near the river," June, 1866, *Bolander 4845* (GH, TYPE; US; UC, four sheets); Merced, June, 1878, *Bush* (GH); Merced Plains, July 15, 1896, *Jepson 100h* (J).

M. leucocephala is a very distinct and interesting plant; it is to be regretted that it is not better known. The matured calyces fall away, leaving a roughened cruciate receptacle which persists.

INDEX TO SPECIES

Synonyms are printed in *italics*; species or genera maintained in this paper are printed in Roman type; new species, subspecies, or combinations are indicated in **bold face** type.

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Explanation of Plate

PLATE I

Map of western United States, showing distribution of *M. odoratissima*.

P —*M. odoratissima* subsp. *pallida*
E —*M. odoratissima* subsp. *euodoratissima*
D —*M. odoratissima* subsp. *discolor*
Po —*M. odoratissima* subsp. *pinetorum*
Pv —*M. odoratissima* subsp. *parvifolia*
A —*M. odoratissima* subsp. *australis*
G —*M. odoratissima* subsp. *glauca*

MAP
OF THE
CORDILLERAN REGION
SHOWING THE DISTRIBUTION
OF
WOODS AND FORESTS
LEGEND

Explanation of Plate

PLATE 2

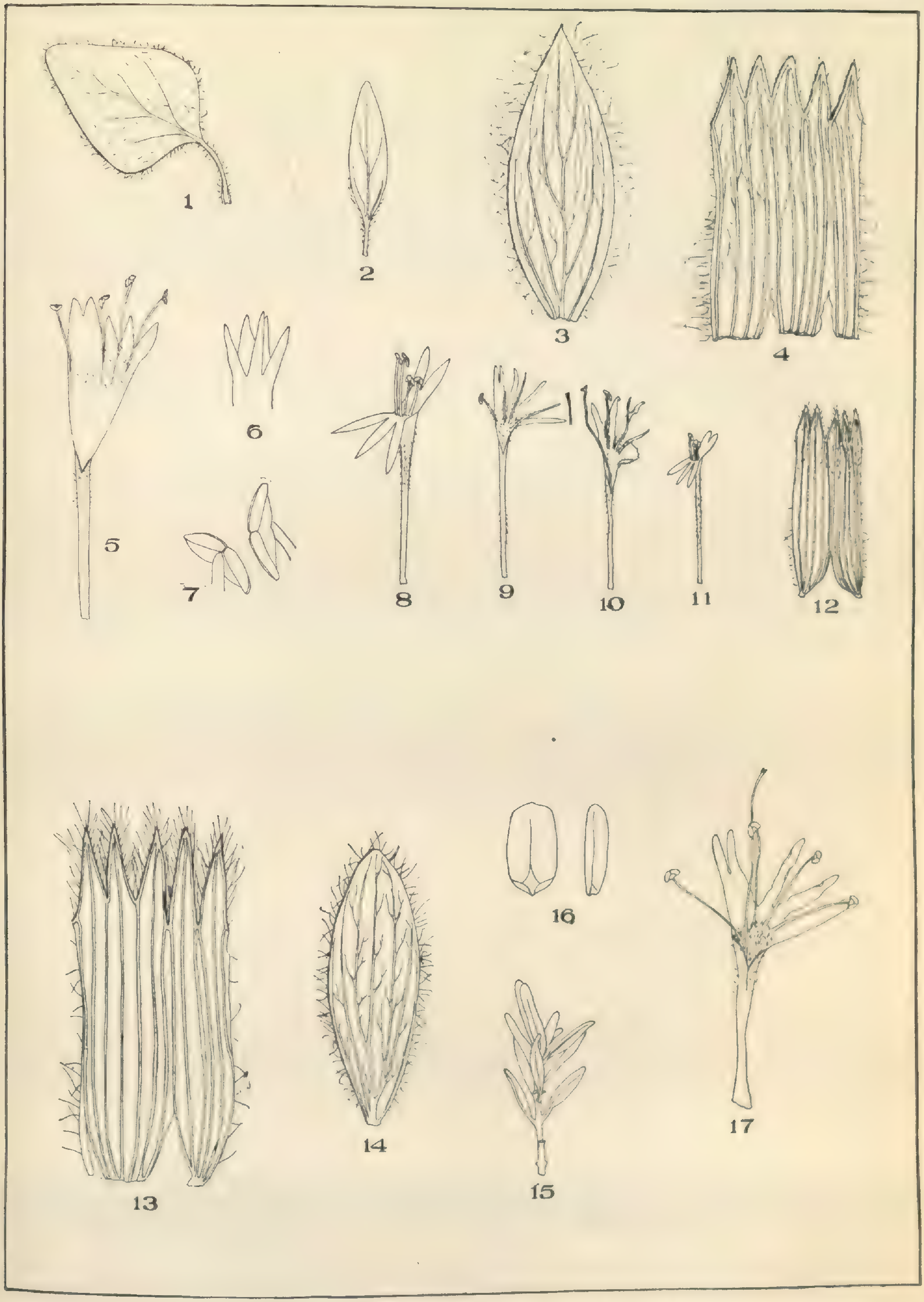
Monardella macrantha

Fig. 1. Leaf of var. *Hallii*, × 2.
Fig. 2. Leaf of subsp. *eumacrantha*, × 2.
Fig. 3. Bract, × 5.
Fig. 4. Calyx of subsp. *eumacrantha*, × 4.
Fig. 5. Corolla of subsp. *eumacrantha*, × 2.
Fig. 6. Limb of var. *Hallii*, × 2.
Fig. 7. Anthers, × 20.
Fig. 8. Corolla of var. *tenuiflora*, × 2.
Fig. 9. Corolla of subsp. *nana*, × 2.
Fig. 10. Corolla of subsp. *nana*, × 2 (from type).
Fig. 11. Corolla of var. *arida*, × 2.
Fig. 12. Calyx of subsp. *nana*, × 2.

Monardella Palmeri

Fig. 13. Calyx, × 10.
Fig. 14. Bract, × 5.
Fig. 15. Foliage, × 5.
Fig. 16. Nutlets, × 20.
Fig. 17. Corolla, × 5.

All drawings of *M. Palmeri* are from the type.



EPLING—MONOGRAPH OF MONARDELLA

Explanation of Plate

PLATE 3

Monardella villosa

Fig. 1. Corolla of subsp. *euvillosa*, × 5.
Fig. 2. Bract, × 5 (villosity not shown).
Fig. 3. Corolla of var. franciscana, × 5.
Fig. 4. Anthers, × 25.
Fig. 5. Calyx, × 10.
Fig. 6. Outer bract, × 5 (villosity not shown).
Fig. 7–16. Leaves of various types, pubescence not shown.

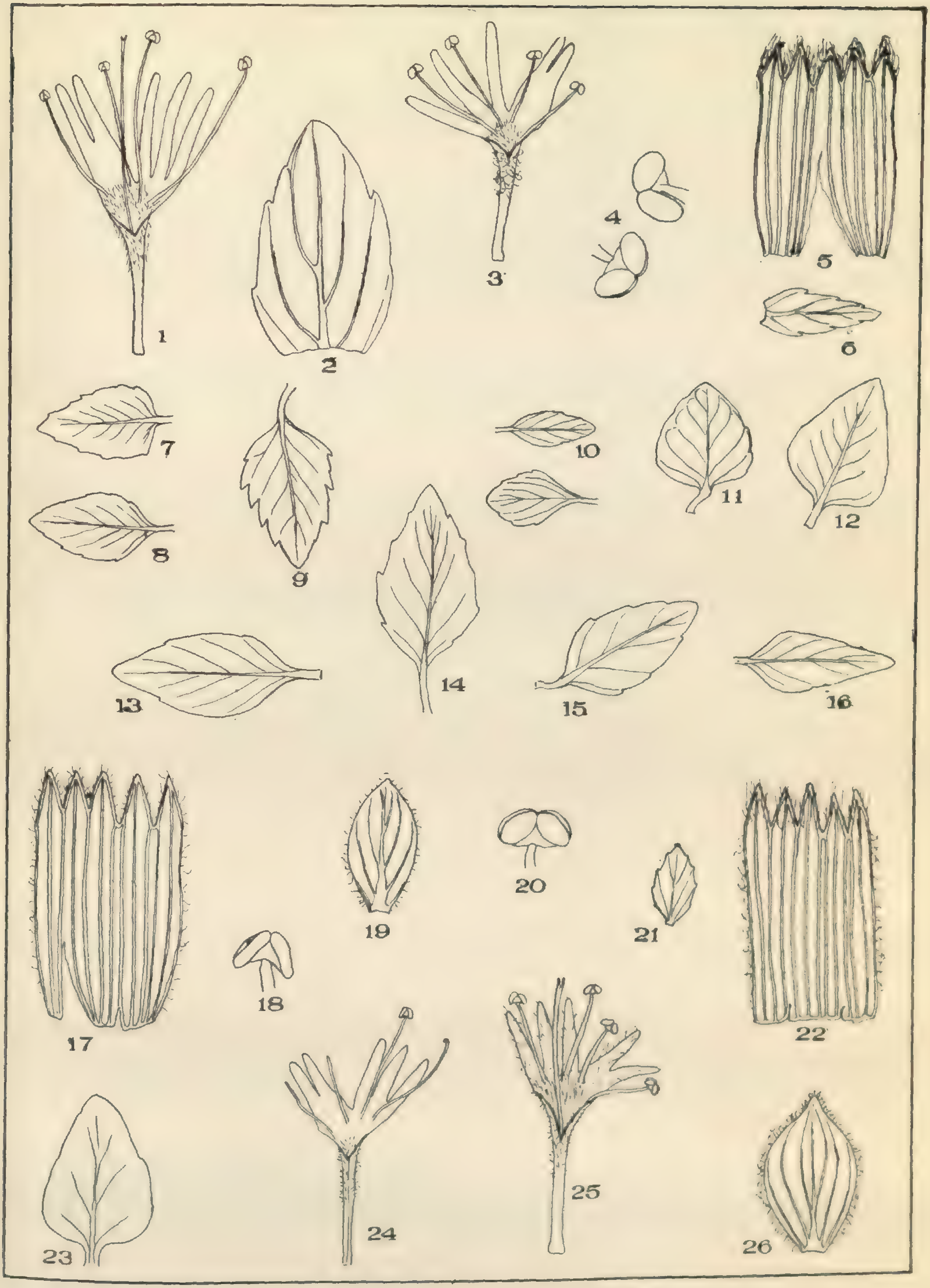
M. thymifolia

Fig. 17. Calyx, × 10.
Fig. 18. Anthers, × 20.
Fig. 19. Bract, × 5.
Fig. 23. Leaf, × 5 (villosity not shown).
Fig. 24. Corolla, × 5.

M. cinerea

Fig. 20. Anther, × 20.
Fig. 21. Leaf, × 2.
Fig. 22. Calyx, × 10.
Fig. 25. Corolla, × 5.
Fig. 26. Bract, × 5.

Drawings made from type.



EPLING—MONOGRAPH OF MONARDELLA

Explanation of Plate

PLATE 4

Monardella hypoleuca

Fig. 1. Calyx, × 10.
Fig. 2. Anther, × 25.
Fig. 3. Corolla, × 5.
Fig. 4. Bract, × 4.
Fig. 5. Leaf, upper surface, × 2.
Fig. 6. Leaf, lower surface, × 2.

Drawings made from type.

M. lanata

Fig. 7. Corolla, × 5.
Fig. 8. Leaf, × 2.
Fig. 9. Anthers, × 25.
Fig. 10. Calyx, × 10.
Fig. 11. Leaf, lower surface, × 2.
Fig. 12. Leaf, lower surface, × 2 (villosity not shown).
Fig. 13. Leaf, upper surface, × 2 (villosity not shown).
Fig. 14. Bract, × 5.

Drawings made from type collection.

M. saxicola

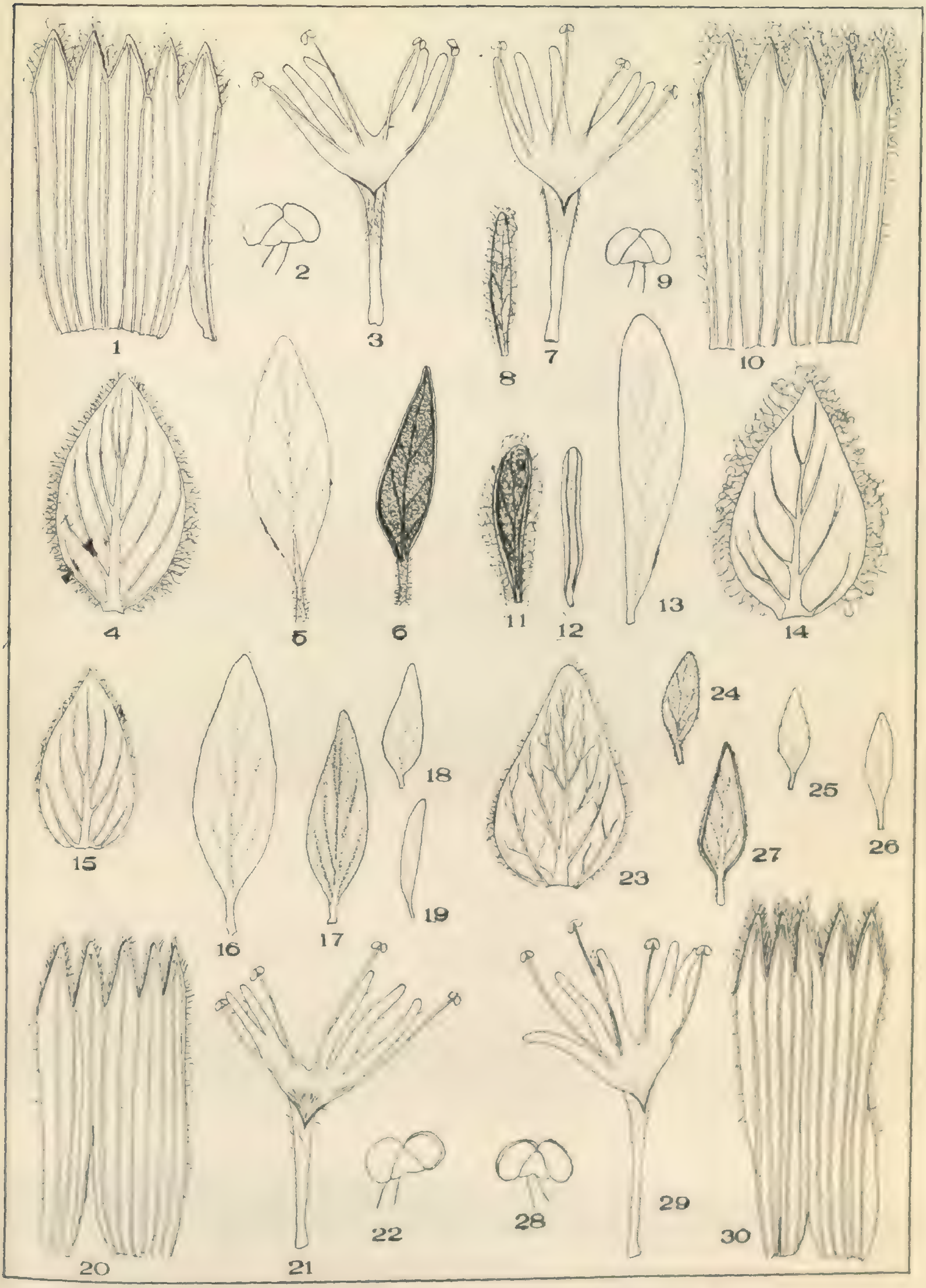
Fig. 15. Bract, × 5.
Fig. 16. Leaf, upper surface, × 2.
Fig. 17. Leaf, lower surface, × 2.
Figs. 18–19. Leaves, upper surface, × 2.
Fig. 20. Calyx, × 10.
Fig. 21. Corolla, × 5.
Fig. 22. Anther, × 25.

Drawings made from type.

M. viridis

Fig. 23. Bract, × 5.
Figs. 24–26. Leaf, upper surface, villosity not shown in last two, × 2.
Fig. 27. Leaf, lower surface, × 2.
Fig. 28. Anthers, × 25.
Fig. 29. Corolla, × 5.
Fig. 30. Calyx, × 10.

Drawings made from type collection.



EPLING—MONOGRAPH OF MONARDELLA

Explanation of Plate

PLATE 5

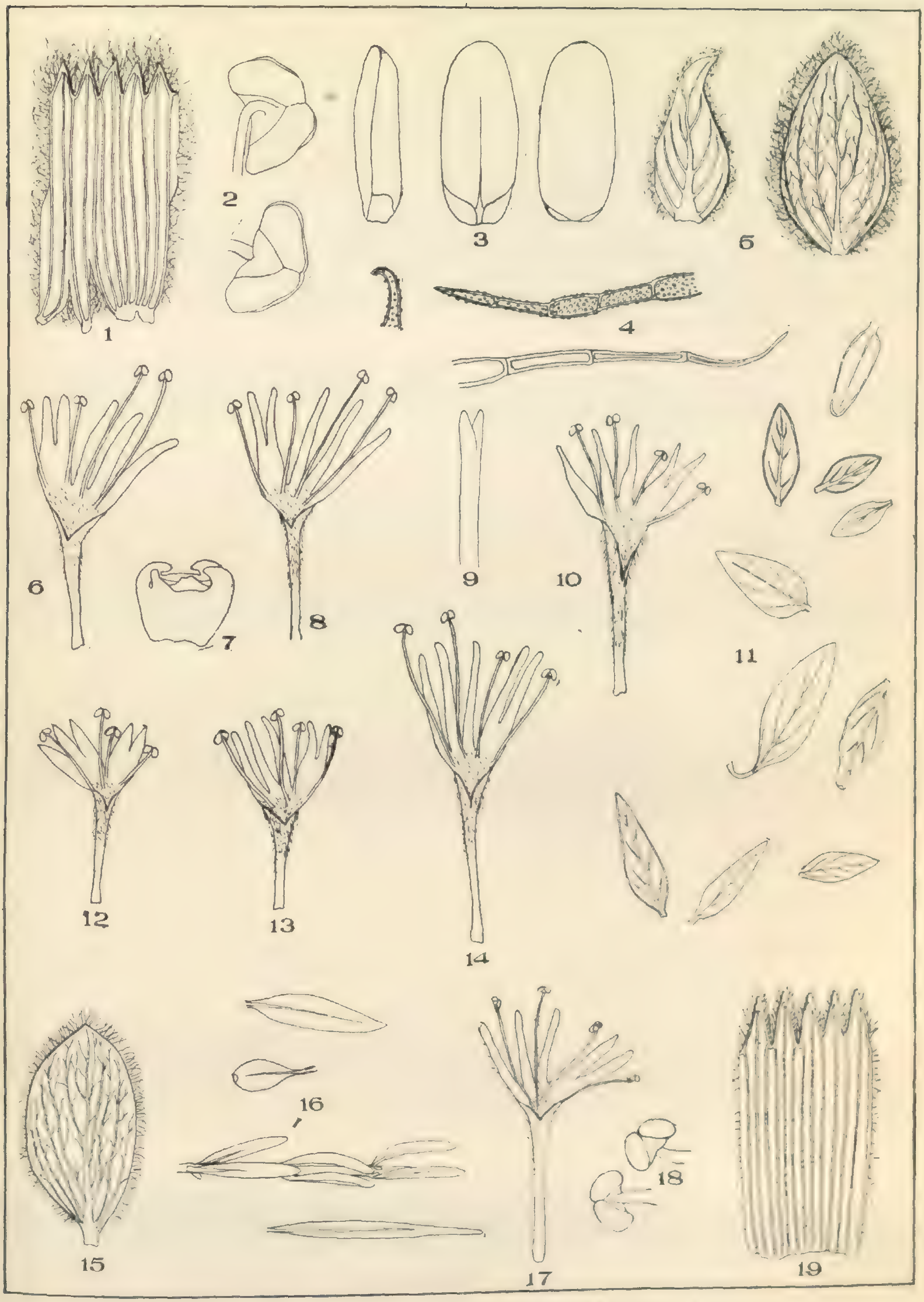
M. odoratissima

Fig. 1. Calyx, × 5 (subsp. discolor).
Fig. 2. Anthers, × 50.
Fig. 3. Nutlets, × 50.
Fig. 4. Trichomes common to the genus.
Fig. 5. Bracts, × 5.
Fig. 6. Corolla of subsp. *discolor*, × 5.
Fig. 7. Gynobase after nutlets have fallen, × 50.
Fig. 8. Corolla of subsp. *euodoratissima*, × 5.
Fig. 9. Tip of style, × 50.
Fig. 10. Corolla of subsp. *glauca*, × 5.
Fig. 11. Types of foliage, × 2 (pubescence not shown).
Fig. 12. Corolla of subsp. *pallida*, × 5.
Fig. 13. Corolla of subsp. *parvifolia*, × 5.
Fig. 14. Corolla of subsp. *australis*, × 5.

The corollas represented above are those which are common in the subspecies indicated. All gradations may be found.

M. linoides

Fig. 15. Bract, ×5.
Fig. 16. Types of foliage, × 2 (pubescence not shown).
Fig. 17. Corolla, × 5.
Fig. 18. Anthers, × 20.
Fig. 19. Calyx, × 10.



EPLING—MONOGRAPH OF MONARDELLA

Explanation of Plate

PLATE 6

M. undulata

Fig. 1. Calyx, × 10.
Fig. 2. Foliage, × 2 (pubescence not shown).
Fig. 3. Anther, × 25.
Fig. 4. Bracts, × 5 (the second outermost).
Fig. 5. Corolla, × 5.
Fig. 6. Leaf, × 2.

M. Douglasii

Fig. 7. Bracts, × 5 (the second innermost).
Fig. 8. Calyx, × 10.
Fig. 9. Anthers, × 25.
Fig. 10. Corolla, × 5.
Fig. 11. Foliage, × 2.

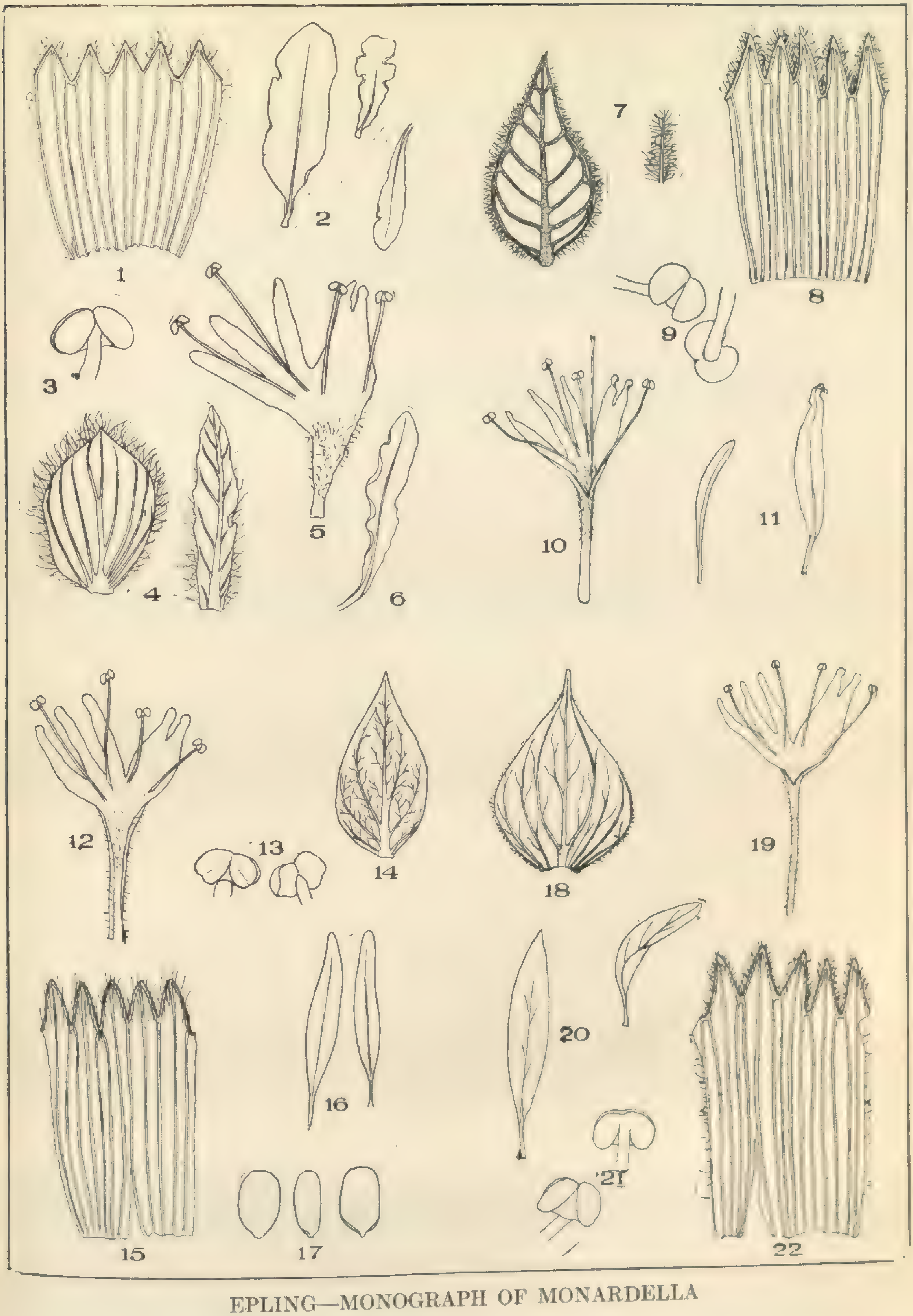
M. lanceolata.

Fig. 12. Corolla, × 5.
Fig. 13. Anthers, × 25.
Fig. 14. Bract, × 5.
Fig. 15. Calyx, × 10.
Fig. 16. Foliage, × 2.
Fig. 17. Nutlets, × 10.

M. Breweri

Fig. 18. Bract, × 5.
Fig. 19. Corolla, × 5.
Fig. 20. Foliage, × 2
Fig. 21. Anthers, × 25.
Fig. 22. Calyx, × 10.

Drawings made from type.



EPLING—MONOGRAPH OF MONARDELLA

Explanation of Plate

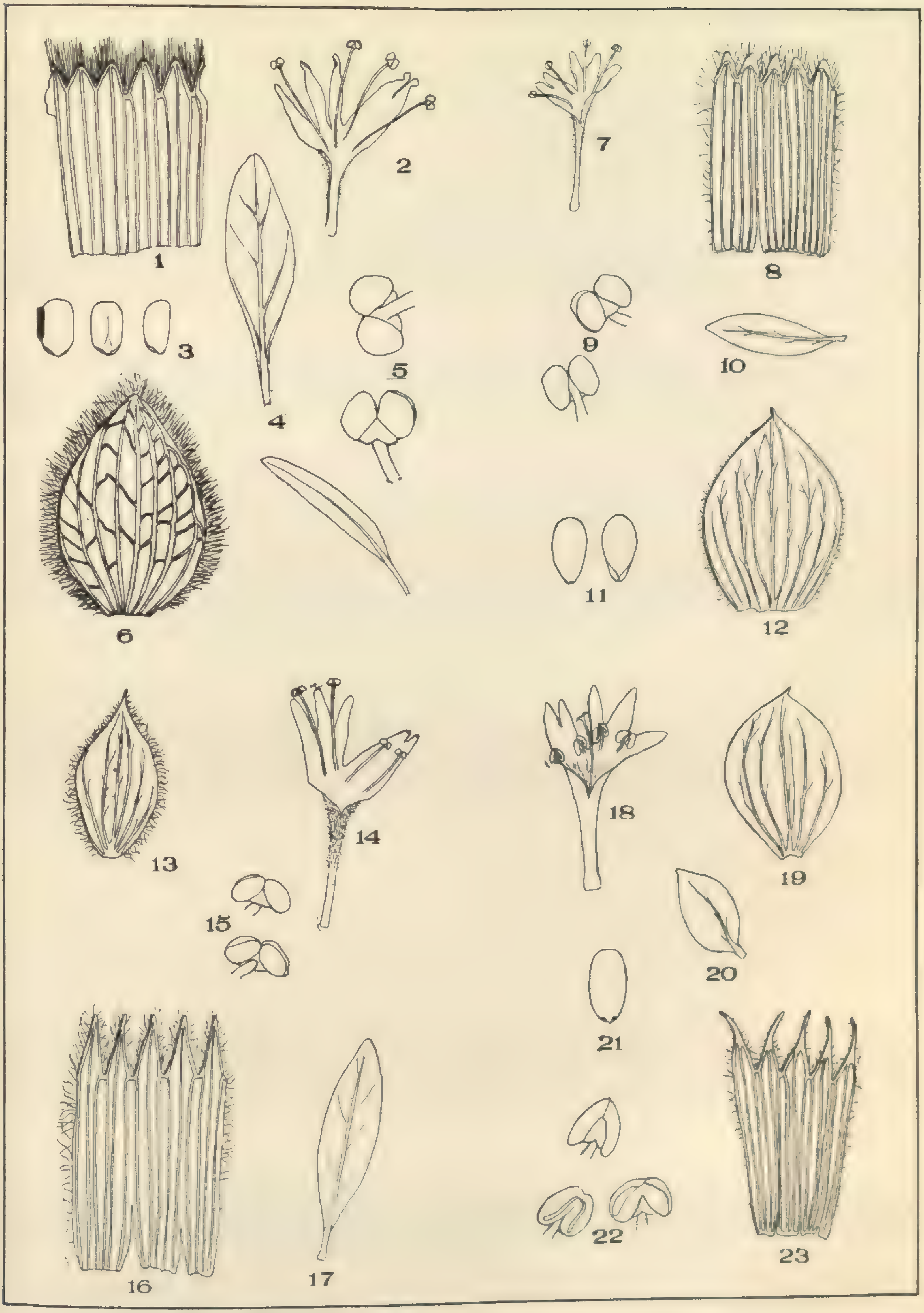
PLATE 7

M. candicans
Fig. 1. Calyx, × 10
Fig. 2. Corolla, × 5
Fig. 3. Nutlets, × 10.
Fig. 4. Foliage, × 2.
Fig. 5. Anthers, × 25.
Fig. 6. Bract, × 5.

M. exilis
Fig. 7. Corolla, × 5.
Fig. 8. Calyx, × 10.
Fig. 9. Anthers, × 25.
Fig. 10. Leaf, × 2.
Fig. 11. Nutlets, × 10 (? mature).
Fig. 12. Bract, × 5.
Drawings made from type.

M. Pringlei
Fig. 13. Bract, × 5.
Fig. 14. Corolla, × 5.
Fig. 15. Anthers, × 20.
Fig. 16. Calyx, × 10.
Fig. 17. Leaf, × 2.
Drawings made from type collection.

M. leucocephala.
Fig. 11. Corolla, × 10.
Fig. 12. Bract, × 5.
Fig. 20. Leaf, × 2.
Fig. 21. Nutlet, × 10.
Fig. 22. Anthers, × 35.
Fig. 23. Calyx, × 10.
Drawings made from type.



EPLING—MONOGRAPH OF MONARDELLA

STUDIES ON SOUTH AMERICAN LABIATAE. I

Synopses of the Genera Teucrium, Rosmarinus, Marrubium, Prunella, Lamium, Leonurus, and Leonotis

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Foreword

The botanical exploration of the past decade which has had South America as its field has resulted in the accumulation among other things of a considerable quantity of specimens of the *Labiatae* of that region. These collections, as far as this family of plants is concerned, have been critically studied in but very few instances, and for the most part the specimens have been determined only to the genus. The same is true of the collections of earlier date as they are represented in the larger herbaria of the United States. It has been the author's privilege to have placed at his disposal for study the collections of South American *Labiatae* in the herbaria of the Missouri Botanical Garden, the United States National Herbarium, the Field Museum of Chicago, the Academy of Natural Sciences of Philadelphia, the Gray Herbarium of Harvard University, the University of California, and the New York Botanical Garden.[1] The names of the principal collectors whose collections are represented in these herbaria, together with the country in which the collections were made and the year, are listed below.

J. Dombey	Peru	about 1780
H. B. Fielding	Chili	
C. F. Ph. von Martius	Brazil	1817–1821
A. Bonpland	Colombia	

[1] The following abbreviations are used herein: ASP, Academy of Natural Sciences of Philadelphia; FM, Field Museum of Natural History; GH, Gray Herbarium; MBG, Missouri Botanical Garden; NY, New York Botanical Garden; UC, University of California; US, United States National Herbarium.

Issued September 28, 1925.

Fr. Sello (Sellow)	Brazil	1819
C. H. Mertens	Chili	(?)1827
C. J. Bertero	Chili	1827
Cl. Gay	Chili	1828–1834
W. Jameson	Ecuador	(?)1831–32
J. Tweedie	Brazil	1837
R. H. Schomburgk	British Guiana	1837–43
G. Gardner	Brazil	1838–1840
Wilkes Exped.	Argentina-Chili	1838–1842
Commerson	Uruguay and Argentina	1840
H. F. A. von Eggers	Ecuador	1840
Styles	Chili	
T. Hartweg	Colombia	1841–43
Glaziou	Brazil	
P. Salzmann	Brazil	(?)1844
J. Gillies	Argentina-Chili	1851
N. J. Anderson	Galapagos	1852
Page	Argentina	1854
A. Fendler	Venezuela	1854–1855
R. Spruce	Ecuador	1855–1859
W. H. Harvey	Chili	1856
G. Mandon	Bolivia	1860
A. F. Regnell	Brazil	1866
P. G. Lorentz & G. Hieronymus	Argentina	1872
O. Kuntze	Venezuela	1874
G. Hieronymus	Argentina	1876
J. Ball	Chili	1882
F. C. Lehmann	Colombia-Ecuador	1881–1883
Safford	Uruguay	1886
Wm. Geisse	Chili	1887
T. Morong	Paraguay	1888–1890
A. M. Bang	Bolivia	1891–1892
G. Baur	Galapagos	1891
O. Kuntze	Argentina	1891–1892
H. H. Rusby & Roy W. Squires	Venezuela	1896
O. Buchtien	Chili	1895–1896, 1903

A. H. Moore	Venezuela	1899
G. T. Hastings	Chili	1900
K. Fiebrig	Paraguay	1902
H. Pittier	Colombia	1905–1906
A. Stewart	Galapagos	1906
O. Buchtien	Bolivia	1906–1919
K. Fiebrig	Paraguay	1909–1910
A. Jahn	Venezuela	1910
H. Pittier	Venezuela	1913–1921
E. Hassler	Paraguay	1913
P. Dusèn	Brazil	1914
Bro. Ariste-Joseph	Colombia	1914
O. F. Cook & G. B. Gilbert	Peru	1915
W. Fischer	Argentina	1915
A. Weberbauer	Peru	1915
P. Jörgensen	Argentina	1915–1917
H. H. Rusby & F. W. Pennell	Colombia	1917
F. W. Pennell	Colombia	1917–1918
J. N. Rose	Ecuador	1918
Bro. Claude-Joseph	Chili	1918–1923
A. S. Hitchcock	British Guiana	1919
E. W. D. & M. M. Holway	Chili	1919
A. S. & M. Kalenborn	Peru	1919
H. A. Gleason	British Guiana	1921
J. F. Macbride & Featherstone	Peru	1922
F. W. Pennell	Colombia	1922
F. W. Pennell & E. P. Killip	Colombia	1922
E. P. Killip & Bro. Ariste-Joseph	Colombia	1922
Bro. Ariste-Joseph	Colombia	1922
E. P. Killip	Colombia	1922
F. W. Pennell, E. P. Killip & T. Hazen	Colombia	1922
W. E. Broadway	Venezuela	1923

J. S. De La Cruz	British Guiana	1920-23
G. H. Pring	Colombia	1923
F. M. Macbride	Peru	1923
H. E. Anthony & G. H. Tate	Ecuador	1923
A. S. Hitchcock	Ecuador	1923
E. Werderman	Chili	1924

The present paper offers a synopsis of the species belonging to the genera named in the title, together with their distribution as represented by the above-named collections. With the exception of *Teucrium*, the genera are monotypic for this region, and of these monotypic genera all but *Prunella* are introduced and naturalized, some growing as wayside weeds. *Prunella vulgaris* is cosmopolitan. *Teucrium*, however, is represented in South America by approximately five species.

While recent years have added very greatly to the exsiccatae available for study, nevertheless the fact remains that numerous species are represented in the above-named collections by a single specimen or not at all. Furthermore, the majority of types and historical collections are to be found in European herbaria. These types have not yet been studied by the author. By reason of these facts, then, the proposed papers, of which this is the first, are not monographic in nature but in many cases include tentative dispositions which may or may not be changed upon accession of additional specimens or after study of certain types. Accordingly, for the present, where doubt exists, changes in nomenclature, which may eventually be necessary, will be only indicated.

In spite of the fact that these notes are incomplete their publication is thought desirable by reason of their possible bearing first upon field study and secondly upon herbarium study of the collections already made. In the first instance it is hoped that the descriptions and keys will permit of identification and study in the field and will stimulate the preservation of variant forms and the collection of seed for garden study. In the second instance it is hoped that the determination of unnamed herbarium specimens will be greatly facilitated.

The work outlined in the following notes was done largely at

the Missouri Botanical Garden during the summer of 1924. The author is accordingly greatly indebted to the Director of that institution for the excellent facilities afforded. He is no less obligated to the directors of the various herbaria listed above who have so generously loaned very valuable material.

Teucrium (Tourn.) L.

Herbae fruticesve floribus in his speciebus ad ramorum extremitates sitis vel racemoso-spicatis vel patento-racemosis; verticillastris densis, 2–6-floribus, bracteis differentibus; floribus in axillis bracteorum foliosorum solitariis; calycibus tubulosis vel campanulatis frequenter leviter inflatis, 10-venis, quinquedentatis, dentibus subaequalibus vel posticis latioribus; corollae tubo brevissimo in calyce incluso, intus inannulato, frequenter fauce paulo constricto, limbo pro rata longissimo, labro inciso, in calyce incluso vel paulo exserto, eius lobis labioli laterales subaequantibus, labiolo trifido, lobo medio ovato, prominenter declinato-patente, lateralibus oblongis minoribus; staminibus quatuor, didymis, anticis longioribus, omnibus e labri sinu exsertis, declinato-arcuatis; antheris rotundatis, thecis confluentibus; stylo subaequaliter bifido; nuculis hilo prominentiore et laterali, rugoso-reticulatis, maturis cohaerentibus.

Conspectus Specierum

A. Flores in axillis bracteorum foliosorum solitarii.
  a. Folia caulinaria subintegra, floralia saepius trilobata .... *3. T. bicolor*
  b. Folia caulinaria 3–5-fida vel -lobata, floralia trifida.
    α. Calycis lobi tubo aequilongi .... *2. T. nudicaule*
    β. Calycis lobi tubo duplo longiore .... *1. T. cubense*
B. Flores in racemosis spicis extremis dispositi.
  a. Folia obtusa; corolla fauce lata 3–3.5 mm .... *6. T. tenuipes*
  b. Folia acuta; corolla fauce lata 2–2.5 mm.
    α. Planta breviter et dense pubescens; corolla longa 9–12 mm... *4. T. inflatum*
    β. Planta pilosa; corolla longa 10–15 mm .... *5. T. palustre*

1. **T. cubense** Jacq. Enum. Syst. Pl. Carib. 25. 1760, et Select. Stirp. Amer. Hist. **1:** 172, *pl. 63, fig. 74.* 1763.

Herba gracilis altitudine 20–50 cm., in basi ramosa, ramis adscendentibus, virgatis vel iterum ramosis, glabris vel puberulis, quadratis, saepe canaliculatis, angulis acutis; foliis obovatis vel

oblanceolatis, 1–4 cm. longis, glabratis, obtusis, basi cuneatis et in petiolam brevem coarctatis, caulinariis maxime diversitatis, vel in lobos tres obscure incisis, segmento medio majore, omnibus saepius crenato-dentatis, dentibus 8–10, obtusissimis, vel in segmenta linearia tria quinqueve partitis, floralibus saepius 3-fidis, lobis linearibus, subaequalibus, frequenter tamen foliis caulinariis similibus; floribus oppositis, solitariis, decussatim instructis; calycibus campanulatis, florentibus 5–8 mm. longis, dentibus anguste lanceolatis, acutis, tubo duplo longioribus, pedicellis 4–5 mm. longis; corollis 8–10 mm. longis, tubo 1.5–2 mm. longo, lobis labri oblongis, 2–2.5 mm., obtusis, labiolo 6–7 mm. longo, lobis lateralibus lobos labri subaequantibus, lobo medio obovato, 6 mm. longo, in basi angustato; staminibus ad faucem sitis, 7–9 mm. longis, stylo paulo longiore; nuculis 2.5–3.5 mm. longis, valde rugoso-reticulatis, fuscis, maturis calycis tubum superantibus, hilo 1.8–2.3 mm. longo.

Conspectus Subspecierum

Planta glabra; calycis tubus maturus non auctus..........subsp. *Chamaedrifolium*
Planta puberula; calycis tubus maturus patenter auctus, forma hemisphaerii, diametro 4–5 mm..subsp. *cordobense*

a. Subsp. **Chamaedrifolium** (Mill.) comb. nov.

T. Chamaedrifolium Mill. Gard. Dict., ed. 8, n. 16. 1768.

T. laevigatum Vahl, Symb. **1**: 40. 1790 (non Solander in Russ. Nat. Hist. Aleppo, ed. 2, **2**: 255. 1794).

Planta glabra, foliis maximam partem in lobos tres incisis, segmento medio majore, crenato-dentatis, dentibus 8–10, obtusissimis; calycibus florentibus 5–6 mm. longis, fructiferibus 7 mm. longis, lobis acutis, in basi 1 mm. latis, tubo 2 mm. longo, vix aucto; corolla caerulea vel albida.

The plant which occurs at Buenos Aires is apparently the same as that which is distributed throughout the West Indies and along the shores of the Gulf of Mexico from Florida to Yucatan, the type locality of which is Cuba. The leaves may vary greatly upon an individual or may be nearly of a kind. At one extreme they may be merely dentate-crenate or crenately 8–10-lobed, the lobes being subequal and very blunt; at the other extreme they may be irregularly incised into three prin-

cipal obovate or oblanceolate segments, of which the middle one is clearly the largest and usually crenately lobed though frequently entire. The leaf subtending the lowest part of the inflorescence is but rarely parted into linear segments. The floral leaves, however, are for the most part three-parted into linear segments but may occasionally be merely toothed.

Specimens examined:

ARGENTINA: Buenos Aires, 1837, *Tweedie* (NY).

b. Subsp. **cordobense** subsp. nov.

T. Grisebachii Hieron., nom. nudum in Gris. Symb. ad Floram Argent. 275. 1879.

T. cubense Grisebach, *l. c.* 275. 1879.

Planta puberula, cinerea, foliis maximam partem in segmenta linearia tria quinqueve partitis; calycibus florentibus 5–7 mm. longis, fructiferibus 7–9 mm. longis, lobis obtusiusculis, in basi 1–1.2 mm. latis, tubo 2.5–3 mm. longo, patenter nuculis distento, forma hemisphaerii, diametro 4–5 mm., dentibus nonnihil auctis, super nuculos subconniventibus sinibus rotundatis; corolla "luride rubescentibus" (Hieron.).

Specimens examined:

ARGENTINA: Sierra de Cordoba, Feb. 14, 1876, *Hieronymus 390* (FM; US); El Sancho, Catamarca, 1700 m., Nov. 12, 1916, *Jörgensen 1296* (US), May 22, 1915, *Jörgensen 1296* (MBG), May 12, 1915, *Jörgensen 1296* (GH); Ischilin, 1892, *Kuntze* (US, TYPE; NY); Cordoba, en las Quintas, Oct. 1883, *Galander* (NY); Potrero de Lujan, Cordoba, Dec. 25, 1883, *Galander* (NY); Cordoba, Dec. 1891, *Kuntze* (NY); Cordoba, Altos del Observatoro, Nov.–Dec. 1891, *Kurtz 7260* (NY).

A note on the label of the Hieronymus collection at the Field Museum reads "Am Fuss der Cuesta de las Chacras zw. Devisaderos u. Taninga; Westseite der Sierra de Cordoba."

2. **T. nudicaule** Hooker, Bot. Miscellany **2**: 235. 1831.

? *T. tripartitem* Meyen, Reise **1**: 406. 1843.

Suffrutex, altitudine 20–(?)40 cm., ramis numerosis e corona lignosa, adscendentibus, virgatis, puberulis, quadratis, angulis obtusis, internodiis ramorum fertilium quam foliis duplo triplove longioribus, eis in ramis sterilium 2 cm. longis, in segmentis

linearibus acutis profunde tripartitis, segmento medio paulo longiore, eis in ramis fertilium 7–15 mm. longis, vel ad basim vel ad medium tripartitis, omnibus puberulis; floribus oppositis, decussatim instructis, in racemis extremis dispositis, racema virgata vel ramosis, ramis distantibus, gracilibus, divaricatis; bracteis foliosis; calycibus 3–5 mm. longis, campanulatis, puberulis, lobis tubo aequilongis, lanceolatis, subacuminatis, fructiferibus vix auctis, pedicellis 4–5 mm. longis elatis; corollis 12–15 mm. longis, extus pubescentibus, tubo 2–3 mm. longo, ad bases staminum pubescente, lobis labri oblongo-ovatis 7 mm., labiolo 10–13 mm. longo, lobis lateralibus oblongis 5 mm., lobo medio oblongo-rotundato, 8–10 mm. longo, staminibus ad faucem sitis, 12 mm. longis, ad basim hirtellis; stylo paulo longiore; nuculis oblongis, 3 mm. longis, 1.2 mm. latis, atris, asperulis, hilo nigro, parte dimidia quam nucula breviore.

The middle lobe of the lower lip is apparently of a deep purplish color, the remainder of the corolla being lighter in shade as in *T. bicolor*. The species is reported by Gay from Copiapo, Coquimbo, and Arqueros. The type locality is uncertain.

Specimens examined:

CHILI: Desert of Atacama, 1885–7, *Geisse 71* (NY); no data, *Gay* (GH).

Var. **leucanthum** (Phillipi), comb. nov.

T. leucanthum Phillipi, An. Univ. Chili **90**: 565. 1895.

Planta 20 cm. alta, foliis 8–10 mm. longis, confertissimis, corolla alba (Phillipi).

Not improbably a drought form of *T. nudicaule.* Phillipi gives the following note: "Las hojas son casi sesiles, las mas veces mucho mas pequenas que en el *T. nudicaule* i apenas partidas mas alla del medio i las lacinias esteriores a menudo provistas de un lobulo de modo que las hojas parencen casi quinquefidas; las flores son axilares i solitarias i cortamente pediceladas. En otros ejemplares las hojas son mas profundamente partidas, i sus divisiones provistas de dos a cuatro lobulitos de cada lado." His type is a collection made by Bouchers near Taltal in October, 1887.

The label of the Ball collection at the Gray Herbarium bears

the following annotations: "ramis dense foliaceis floribus approximatis," "only three phanerogams were seen on the coast at that place."

Specimens examined:

CHILI: ex rupestribus chilensibus juxta Taltal, May, 1882, *Ball* (US; GH; NY).

3. **T. bicolor** Smith in Rees, Cyclopedia **35**: no. 25. 1819.

T. heterophyllum Cav. Icones **6**: 56. *pl. 577.* 1801 (non *T. heterophyllum* L'Herit. Stirp. Nov. 84. *fig. 49.* 1784–85).

T. orchideum Lindl. Bot. Reg. **15**: *pl. 1255.* 1829.

T. Cavenellesii Bert. ex Steud. Nom., ed. 2, **2**: 674. 1841 (nom. nudum).

T. chilense Desf. ex Steud. Nom., ed. 2, **2**: 674. 1841 (nom. nudum).

Frutex 2 m. altitudine, multo ramosis, foliosis, ramis teretibus, cortice discedente, ramulis gracilibus, puberulis, quadratis, angulis acutis, marginatis, internodiis plerumque foliis subaequalibus vel brevioribus; foliis forma diversis, oblanceolatis 1.5–2.5 cm. longis, trivenis, obtusis, in basi ad brevem petiolam angustatis, puberulis, margine revoluta, integra vel diverse dentata vel lobata, maximam partem dentibus duobus ad medium, his 1–2 mm. longis, ovatis, obtusis, divergentibus; floribus in racemis extremis in axillis foliorum solitariis, decussatim instructis; calycibus 5–7 mm. longis, lobis tubo aequilongis, lanceolatis, acutis, fructiferibus vix auctis, pedicellis 4–5 mm. longis elatis; corollis 18–20 mm. longis, extus pubescentibus, tubo 3–4 mm. longo, ad bases staminum hirsuto, labri lobis oblongis, obtusis, 5–6 mm., labiolo 12 mm. longo, lobis lateralibus ovatis, majoribus quam labri lobis, 5–6 mm. longis, lobo medio 10 mm. longo, oblongo-rotundato, in basi subtruncato, purpureo, corolla alia alba; staminibus ad faucem sitis, 15–18 mm. longis, ad basim valde hirsutis, valde arcuatis; stylo 20 mm. longo, ramis gracilibus, 2 mm. longis, nuculis obovatis, 2 mm. longis, asperulis, fuscis, hilo 1.5 mm. longo.

T. bicolor and *T. nudicaule* are closely allied and appear to have been derived from a common stock, the latter representing an adaptation to a more arid habitat. Their distribution, as far as known, supports this assumption.

T. bicolor is reported by Gay as common in the hills of the central provinces.

Specimens examined:

Chili: Prov. de Chillon, Dec. 1869, *? Couthoy* (FM); Ramon, Nov. 25, 1920, *Bro. Claude-Joseph 1275* (US); *Styles* (ASP); Santiago, San Cristobel, Nov. 3, 1900, *Hastings 119* (US); *Gay 293* (US); Lota, Nov. 7, 1868, *Cunningham* (GH); Valparaiso, *Mertens* (GH); Coquimbo, July–Aug. 1856, *Harvey* (GH); ex regione inferiore Andium Chilensium in Convalle Aconcagua, May 1882, *Ball* (GH; NY); *Gay* (GH); *Bertero 689* (GH); Chili boreale, 1827, *Bertero 1352* (MBG); Valparaiso, *Wilkes Exp.* (US; NY); Costa, Nov. 4, 1920, *Bro. Claude-Joseph 1254* (US); Isle St. Marys, *Eights* (US); Temuco, Dec. 5, 1919, *Holway 200* (US); in the bush near Salto, Valparaiso, Sept. 21, 1895, *Buchtien* (US); Prov. Colchagua, *collector unknown 158* (NY); no data, *Gay 293* (NY); Valparaiso, *Gillies* (NY).

4. **T. inflatum** Swartz, Prod. Veg. Ind. Occ. 88. 1797.

(?) *T. vesicarium* Miller, Gard. Dict., ed. 8, sub *Teucrio*, no. 17. 1768.

Herba, caule erecto e rhizomate repente, frequenter in nodis inferioribus radicante, altitudine 40–90 cm., ramosis in axillis superioribus, quadratis, canaliculatis, angulis obtusis, dense et breviter pubescentibus; foliis ovatis vel lanceolatis, 4–12 cm. longis, vix acuminatis, in basi truncato-cuneatis, margine subduplicato-serrata, crenis 2–3 mm. longis, 1.5–2.5 mm. latis, ovatis, subapiculatis, pagina superiore hirtellis, inferiore pallidiore dense tomentellis, petiolis gracilibus, pubescentibus, 1–3 cm. longis floribus in spicis extremis racemosis 5–20 cm. longis, 1.5 cm. latis congestis, subspirale sed tamen 2–4 floribus in pseudoverticillastris instructis; bracteis lanceolato-linearibus, acuminatis, pubescentibus, pedicellos excedentibus; calycibus campanulato-tubulosis, cano-pubescentibus, bilabiatis, 5–7 mm. longis, inflatis, ore obliquo, dentibus 2 mm. longis, posticis in basi 1.2 mm. latis, triangulo-ovatis, acutis, anticis angustioribus, acuminatis, omnibus conniventibus; corollis 9–11.5 mm. longis, tubo 4–5 mm. longo, lobis labri triangulis, 1 mm. longis, acutis sinu labri 2–3 mm. alto, labiolo 5 mm. longo, extus pubescenti-

bus, lobis lateralibus 1 mm. longis, oblongis, obtusis, lobo medio 3 mm. longo, rotundato-obovato; staminibus 7 mm. longis, ad medium tubi sitis, infra medium hirtellis; stylo staminibus paulo breviore; nuculis 2–2.5 mm. longis, fuscis, valde rugoso-reticulatis, glabris, hilo 1.7–2 mm. longo.

The type locality of *T. inflatum* is Jamaica. The plant is described as "calycibus inflatis, villosis." The type locality of *T. vesicarium* is near Vera Cruz, Mexico. Miller's description was drawn from plants grown in England from seed introduced by Houston. The plant is described as "Calice vesicario" and with "smooth branches." The type locality of *T. palustre* is cited as being between the mouth of the Sinu River and Cartagena in Colombia. The plants collected in this locality by Pennell (which are distinctly pilose) correspond very closely to Kunth's description.

The plants of Jamaica and the West Indies are of the pubescent type and are similar in every way to the plants growing in Brazil, Paraguay, Ecuador and Argentina. On the other hand, all specimens from Mexico which have been examined were definitely pilose and were similar in every way to the plants of Colombia.

Careful measurements of numerous flowers (after boiling) have shown that the Mexican plants in addition to the pilose covering have corollas which are uniformly larger, ranging in length from 10–16 mm. The calyces, too, are somewhat larger (6–9 mm.) and the teeth are usually more acute. The corollas of the West Indian plants and the South American plants other than Colombian are 9–11.5 mm. long with calyces 4.5–7 mm. long. The two groups do intergrade, however, and since their geographical distribution is distinct they are better considered subspecies. Until it is possible to ascertain what plants were actually described by Swartz, Miller, Kunth, and Sprengel, no changes in nomenclature have been made.

Specimens examined:

Brazil: Prov. Sta. Catharina, Tubarao, Jan. 1889, *Ule 1060* (US).

Ecuador: Prov. Guayas, Milagro, 50 m., June 30–July 2, 1923, *Hitchcock 20210* (US; NY); near Guayaquil, *Hartweg 684* (NY); no data, *Eggers* (NY).

Paraguay: in region of Alto Parana R., 1909–10, *Fiebrig 5604* (US; GH); in region of Lake Ypacaray, March, 1913, *Hassler 11462* (US; MBG; GH); Asuncion, 1888–90, *Morong 179* (US; MBG; ASP; GH; NY).

Argentina: El Monte las ? Palan, Nov. 1917, *Jörgensen 2239* (US; MBG; GH).

5. **T. palustre** Kunth in Humboldt, Bonpland & Kunth, Nov. Gen. et Sp. Pl. **2**: 306. 1817 (non *T. palustre* Lam. Fl. Fr. **2**: 411. 1778).

(?) *T. hirtum* Willd. ex Spreng. Syst. **2**: 710. 1825.

Herba, caule erecto e rhizomate repente, frequenter in nodis inferioribus radicante, altitudine 40–90 cm., ramosis in axillis superioribus, quadratis, canaliculatis, angulis obtusis, pilis patentibus vestitis; foliis ovatis vel lanceolatis, 4–12 cm. longis, vix acuminatis, in basi truncato-cuneatis, margine subduplicato-serrata, crenis 2–3 mm. longis, 1.5–2.5 mm. latis, ovatis, subapiculatis, pagina superiore tenuiter pilosa, pilis 1 mm. longis, inferiore pallidiore praecipue ad venos dense pilosa, petiolis gracilibus pilosis 1–3 cm. longis; floribus in spicis extremis racemosis, 5–20 cm. longis, 1.5 cm. latis congestis, subspirale sed tamen 2–4-floribus in pseudoverticillastris instructis, bracteis lanceolatis-linearibus, pilosis, acuminatis, calyces paulo excedentibus; calycibus campanulato-tubulosis, inflatis, breviter pubescentibus, pilis quoque 1 mm. longis ornatis, bilabiatis, 6–8 mm. longis, ore obliquo, dentibus 2 mm. longis, posticis in basi 1.2 mm. latis, triangulo-ovatis, acutis, anticis angustioribus, acuminatis, omnibus conniventibus; corollis 11–16 mm. longis, pallide rubro-violaceis vel albis (Pennell), tubo 5–7.5 mm. longo, fauce 2–2.5 mm. lato, lobis labri 1–1.5 mm. longis, acutis, sinu labri 2.5 mm. alto, labiolo 5 mm. longo, extus pubescentibus, lobis lateralibus 1.5 mm. longis, oblongis, obtusis, lobo medio 3.5–4 mm. longo, rotundato-obovato; staminibus 8 mm. longis, ad tubi medium sitis, infra medium hirtellis; stylo staminibus paulo brevioribus; nuculis 2.5 mm. longis, fuscis, valde rugoso-reticulatis, glabris, hilo 2 mm. longo.

For a discussion of nomenclature see the note to *T. inflatum.*

Specimens examined:

COLOMBIA: Dept. of Bolivar, Cienago de Oro, 50–100 m., meadow, corolla light pink-violet, Jan. 28, 1918, *Pennell 4124* (US; GH); Dept. of Bolivar, tierra alta on Rio Sinu, March 7–10, 1918, meadow along river, 50–80 m., corolla pink-violet, *Pennell 4619* (US; MBG; FM; NY; type locality of *T. palustre* Kunth).

6. **T. tenuipes** sp. nov.

Herba altitudine 20–40 cm., e rhizomate repente, caule gracile, diametro 2 mm., pubescente, quadrato, angulis obtusis, nodiis inferioribus nudis, in nodis superioribus ramosis, ramis subdichotomis; foliis in nodis superioribus confertis, obtusis, 2–6 cm. longis, in basi truncato-cordatis, margine convexo, irregulariter serrato-crenatis, crenarum culminibus 1.5–4 mm. altis, obtusis, apiculatis, inter se 3–6 mm. distantibus, pagina superiore molliter pubescente, inferiore pallidiore, pubescente vel subtomentoso, petiolis gracilibus, 1–3.5 cm. longis; floribus in spicis racemosis extremis, subspirale sed tamen 2–4-floribus in pseudoverticillastris instructis, frequenter oppositis; bracteis lanceolato-linearibus, acuminatis, villosis, pedicellos paulo excedentibus; calycibus 5.5–7 mm. longis, campanulato-tubulosis, subvillosis, bilabiatis, paulo inflatis, ore obliquo, dentibus 2–2.5 mm. longis, posticis in basi 1.5–2 mm., triangulo-ovatis, acutis, anticis angustioribus, fructiferibus vix conniventibus; corollis 11–14 mm. longis, tubo 4 mm. longo, fauce 3–4 mm. lato, lobis labri 1.5–2 mm. longis, sinu labri 3–4 mm., labiolo 5–7 mm. longo, lobis lateralibus 2 mm., oblongis, obtusis, lobo medio 3.5–4 mm. longo, rotundato-obovato; staminibus 10–11 mm. longis, ad tubi medium sitis; stylo staminibus subaequale; nuculis 2.5 mm. longis, fuscis, reticulato-rugosis, hilo 2 mm. longo.

The plants above described have previously been referred to *T. inflatum* Sw. The convex obtuse leaves, with relatively coarser teeth, the differences in habit and in pubescence, and particularly the differences in the proportions of the corolla, which more nearly resembles that of *T. occidentale*, have seemed sufficient reasons for considering them as of a distinct species.

Specimens examined:

Galapagos Isl.: Charles Island, 1852, *Anderson* (GH); Charles Isl., "common among rocks," 446 m., Feb. 27, 1906, *Stewart 3342* (US, type; MBG; GH); Charles Isl., 446 m., Oct. 9, 1905, *Stewart 3343* (GH); Chatham Isl., Wreck Bay, 200 m., Jan. 27, 1906, *Stewart 3345* (US; MBG; ASP; FM; GH); Chatham Isl., Wreck Bay, "common in open places," 200 m., Jan. 27, 1906, *Stewart 3345* (GH); same, Feb. 23, 1906, *Stewart 3344* (GH); Chatham Isl., southwest end, middle region, June, 1891, *Baur 164* (GH).

T. Scorodonia L. has been reported by Phillipi[1] with the following note: "Es planta comun en la mayor parte de Alemania, que parce haber llagado a Chili con semillas de forage. El tallo alcanza a 65 cm. de alto, las hojas suelon tener 27–50 mm. de largo i son mui arrugadas. Los racimos son alargados i flojos, multifloros i las flores amarillentas. No tiene semejanza con ninguna otra planta chilena."

Rosmarinus (Tourn.) L.

Frutex floribus in racemis lateralibus brevibus dispositis, calycibus ovatis-campanulatis, bilabiatis, labio superiore integro, inferiore bifido; corollae tubo exserto, intus inannulato, fauce dilato, limbo bilabiato, labiis subaequalibus, labro erecto, emarginato, labiolo patente trifido, lobo medio maximo, concavo, dependente; staminibus duobus (inferioribus) infra medium cum dente parvo ornatis, arcuatis, e labro exsertis, ad faucem sitis; stylo staminibus aequilongo, ramo superiore brevissimo; nuculis siccis, laevibus.

1. **R. officinalis** L. Sp. Pl. 23. 1753.

R. chilensis Molina, Saggio sulla Storia Nat. de Chili 158. 1782.

Frutex dense ramosus foliosusque altitudine circa 1 m., ramis teretibus, lignosis, glabratis, cortice discedente; foliis linearibus, 1–3 cm. longis, acutiusculis, mucronatis, sessilibus, glabratis, subtus canescentibus, margine integra, valde revoluta; floribus paucis in racemis in ramulis lateralibus, 2–3

[1] An. Univ. Chili **90**: 565. 1895.

cm. longis dispositis, oppositis, in axillis bracteorum solitariis; bracteis membranaceis, ovatis, pedicellis subaequalibus; calycibus 4–4.5 mm. longis, purpurascentibus, ovato-campanulatis, bilabiatis, labio superiore subintegro, inferiore bifido, fauce intus subnudo, pedicellis 2–3 mm. longis elatis; corollis 10–12 mm. longis, albis vel pallide caeruleo-purpurascentibus, tubo exserto, 4–5 mm. longo, inannulato, fauce dilato, labro erecto, 4–5 mm. longo, bifido, lobis ovatis, divergentibus, obtusis, labiolo 8–10 mm. longo, lobis lateralibus oblongis, obtusis, erectis, subtortis, lobo medio magno, 7 mm. longo, concavo-dependente; staminibus 10 mm. longis, arcuatis, e labro exsertis; stylo staminibus paulo longiore.

Cultivated throughout Latin America and apparently naturalized locally.

R. chilensis Molina is not improbably this plant and not *Sphacele campanulata* to which it was questionably referred by Bentham. Kuntze and Briquet, acting upon Bentham's suggestion, have referred it there definitely and have made the combinations *Alguelagum chilense* and *Sphacele chilensis*. The present author has been unable to obtain the first edition of Molina's work except in the French and German translations.[1] These compare closely, however, and in both the supplements to the narrative portion are in Latin and are identical. This appendix contains a systematic arrangement of the plants named in the narrative, grouped according to the system of Linnaeus. Speaking of *R. chilensis*, on page 129 of the French edition, the author says "Le romarin sauvage (5) etant tres refineux, sert, comme plusieurs autres arbustes, pour les fouderies de cuivre." The numeral refers to a footnote giving the latin name, *R. chilensis*, which is listed in the systematic appendix under the class "Diandria, Monogynia." In the second edition of his work Molina makes no mention of *Rosmarinus* but describes a new genus *Phytoxis*, now known as *Sphacele*, and it is with this genus that *Rosmarinus chilensis* has been confused. This plant is listed under the class "Didynamia."

Since Molina states, on the one hand, that his *Rosmarinus*

[1] Molina-Brandis, Versuch einer Naturgeschichte von Chili, 309. 1786; Molina-Gruvel, Essai sur l'histoire naturelle du Chili, 329. 1789.

is used for the table, and, on the other, that *Phytoxis* is very acid and known to the natives as the "devil's shrub" (Alhue Lahuen) and since he places the former under the class "Diandria" and the latter under the class "Didynamia," it seems very improbable that the two are synonymous and very probable that Molina was correct in referring his earlier described plant to *Rosmarinus*, a genus with which he was undoubtedly acquainted at first hand.

Specimens examined:

Peru: Ollantaytambo, 3000 m., May 18, 1915, *Cook & Gilbert 811* (US).

Bolivia: Island of Titicaca (Sonnen Inseln), 384 m., Nov. 1910, *Buchtien* (US).

Marrubium L.

Herbae perennes, saepius tomentosae vel lanatae foliis rugosis, in basi rarius cordatis, saepe incisis, floralibus conformibus, flores superantibus; floribus in verticillastris axillaribus densis; bracteis maximam partem subulatis calycem aequilongis; calycibus tubulosis, 5–10-venis, aequalibus, dentibus 5–10, acutis, subspinosis, subaequalibus, erectis vel saepius ad maturitatem patentibus; corollis tubo incluso, intus nudo vel subannulato, limbo bilabiato, labro erecto, subplano vel concavo, integro vel breviter bifido, labiolo trifido, patente, lobo medio latiore saepius emarginato; staminibus intra tubum corollae inclusis, parvis, antheris bilocularibus, thecis divaricatis, subconfluentibus, omnes subconformibus; styli lobis brevibus, obtusis; nuculis apice obtusis nec truncatis.

1. **M. vulgare** L. Sp. Pl. 583. 1753.

M. hamatum Kunth in Humboldt, Bonpland & Kunth, Nov. Gen. et Sp. Pl. **2:** 310. 1817.

Herba altitudine 60–90 cm., in basi densiore ramosa, ramis adscendentibus vel erectis, iterum in axillis inferioribus ramosis, juventate arachnoideo-canescentibus, ad maturitatem sordido-pannosis, quadratis, angulis obtusis; foliis late ovatis, obtusis, 1.5–3 cm. longis, in basi rotundato-truncatis vel subcuneatis, frequenter ad petiolam angustatis, margine crispo-crenata,

crenarum culminibus 1–1.5 mm. altis, inter se 2–3 mm. distantibus, pagina superiore viride, tenuiter arachnoidea, bullato-rugosissima, inferiore dense cano-arachnoidea, petiolis 1–2 cm. longis, dense cano-arachnoideis elatis; floribus 7–20 in glomerulis globosis densis dispositis, glomerulis inter se 3–5 cm. distantibus; calycibus maturis 5–6 mm. longis, fauce paulo dilatis intus hirsutis, 10-venis, lanatis, sessilibus, dentibus 10–12, subaequalibus, patentibus, subspinosis et hamatis, lanatis; corollis albis, 7–8 mm. longis, tubo crasso, aequale, 5 mm. longo, nectarostegio e pilis brevibus ad basim staminum constante, labiis aequilongis, labro erecto, ad medium bifido, lobis oblongis, labiolo trifido, lobis lateralibus triangulo-oblongis, lobo medio majore, oblongo, crispo; staminibus 2 mm. longis, didymis, ad tubi medium sitis, in basi pubescentibus; stylo incluso, ramis acutis; nuculis 2.5 mm. longis, fuscis, oblongis.

A cosmopolitan weed of semi-arid habitat, appearing along roadways and in fields. Frequently found in uncultivated regions but in association with human activities. The plants may be solitary or gregarious or may form dense patches several feet across, or frequently cover an entire slope.

Specimens examined:

BRAZIL: Minas Geraes, Caldas, Sept. 3, 1861, *Regnell 938* (US).

ARGENTINA: General Roca, Rio Negro Valley, 250–360 m., Nov. 17, 1914, *Fischer 114* (US; MBG; GH).

COLOMBIA: *Moritz 994* (US); Bogota, *Bro. Ariste-Joseph* (US); Loacha, 2500 m., Oct. 1911, *Bro. Apollinare & Bro. Arthur 83* (US).

BOLIVIA: ? Cotani, 2500 m., Nov. 1911, *Buchtien 5881* (US).

ECUADOR: Ambato, Aug. 24–26, 1918, *Rose 23382* (US; GH).

PERU: Mollendo, Aug. 5, 1901, *Williams 2528* (US); Matucana, 2461 m., Apr. 12–May 3, 1922, *Macbride & Featherstone 400* (FM; MBG).

CHILI: Valparaiso, highways, 1895, *Buchtien* (US); Santiago, Nov., 1922, *Bro. Claude-Joseph 1486* (US).

PRUNELLA L.

Herbae perennes floribus in spicis densis extremis, verticillastris 6-floribus; bracteis rotundatis, persistentibus, calyces

aequantibus et cum eis imbricatis; calycibus tubuloso-campanulatis, irregulariter sub-10-venis et reticulato-venulosis, supra planis, bilabiatis, labio superiore plano, lato, truncato, breviter tridentato, inferiore semibifido, segmentis lanceolatis, fauce intus nuda; corollae tubo amplo, subexserto, adscendente, intus ad basim pilis squamisve brevibus annulato, sub fauce subtus inflato, ad faucem paulo contracto, labro erecto, galeato, supra subcarinato, integro, labiolo dependente, lobis lateralibus oblongis, deflexis, medio rotundato, concavo, crenulato; staminibus e tubo exsertis, didymis, filamentis in basi edentulis, glabris, apice praesertim superioribus breviter bidentatis, dente inferiore antherifero; antheris sub labro per paria approximatis, liberis, bilocularibus, loculis distinctis, divaricatis; stylo apice bifido, ramis subulatis; nuculis oblongis, levibus.

I. **P. vulgaris** L. Sp. Pl. 600. 1753.

Brunella aequinoctialis Kunth in Humboldt, Bonpland & Kunth, Nov. Gen. et Sp. Pl. **2:** 323, *pl. 162.* 1817.

Herba perennis altitudine 15–50 cm., in basi ramosis, ramis paucis, decumbentibus, saepe debilibus et prostratis, purpurascentibus, glabratis vel in angulis nodisque hispidulis, quadratis, angulis obtusis; foliis oblongo-lanceolatis, 3–5 cm. longis, acutis vel saepius obtusis, in basi angustatis, frequenter etiam subtruncatis, crassiusculis, supra glabris, infra in venis hispidulis vel utrinque hispidulis, margine integra vel obscure repando-denticulata, petiolis 1.5–2.5 cm. longis elatis; floribus in spicis extremis cylindratis, 2–5 cm. longis; bracteis calyces subaequantibus, rotundatis, abrupte acuminatis, viridibus vel purpurascentibus, frequenter translucentibus, venis reticulatis, margine ciliata; calycibus 6–12 mm. longis, purpurascentibus, hispidis, pedicellis brevibus elatis; corollis violaceis, frequenter albis, 9–15 mm. longis, labro labiolo duplo longiore; nuculis 2 mm. longis, ellipticis.

A cosmopolitan plant appearing in fields and particularly along grassy margins of roadways, or frequently in openings in the forest. While cosmopolitan it appears more commonly in temperate regions and at higher elevations.

Specimens examined:

COLOMBIA: Salento, Caldas, 2100–2500 m., "edge of forest above S.," July 25–31, 1922, *Pennell 8892* (US); San Cristobal, moist brushy mountain slope, 2800 m., Sept. 30, 1917, *Pennell 2307* (US; MBG; GH).

CHILI: Valdivia, highways, 1898, *Buchtien* (US); Temuco, Jan. 1923, *Bro. Claude-Joseph 1950* (US).

LAMIUM L.

Herbae in basi decumbentes, foliis infimis longe petiolatis, parvis, mediis majoribus, in basi saepius cordatis, rugosis, plerumque duplicato- vel inciso-dentatis; floralibus subconformibus, superioribus minoribus, sessilioribus, omnibus calyces superantibus; floribus in verticillastris densis, inferioribus vel omnibus remotis, superioribus saepius approximatis; bracteis paucis, calyces brevioribus, subulatis vel rarius lanceolatis; calycibus tubulosis vel turbinato-campanulatis, sub-5-venis, ore aequali vel saepius obliquo, dentibus 5, subaequalibus vel superioribus longioribus, apice subulatis; corollis tubo incluso vel saepius exserto, intus nudo vel piloso-annulato, limbo bilabiato, labro ovato vel oblongo, galeato, in basi plerumque angustato, labiolo fauce dilatato, lobis lateralibus ad margines faucis truncatis vel rarius oblongis, appendicula dentiforme auctis vel muticis, lobo medio emarginato, in basi contracto; staminibus e tubo exsertis, antheris per paria approximatis, bilocularibus, loculis demum divaricatis, oblongis, extus hirsutis vel nudis; stylo apice subaequaliter bifido, ramis subulatis; nuculis triquetris, angulis acutis, apice truncatis, laevibus vel minute tuberculoso-rugosis.

1. **L. amplexicaule** L. Sp. Pl. 579. 1753.

Herba annua 10–30 cm. altitudine, in basi ramosissima, ramis decumbentibus, glabriusculis, purpurascentibus, internodo secundo tertioque frequenter parte dimidia quam caule toto breviore, internodiis superioribus multo brevioribus, quadratis, angulis marginatis; foliis mediis ovato-rotundatis, 1–2 cm. longis, in basi subcordatis, irregulariter crenato-lobatis, obtusis, subhirsutis, petiolis plerumque lamina duplo triplove longioribus; foliis floralibus 1–2 cm. longis, amplexicaulibus, subtus venis

elevatis, hispidulis, supra plerumque villosis, crenato 5–8-lobatis, lobis obtusissimis; floribus in verticillastris compactis, inferioribus distantibus, superioribus approximatis; calycibus 5–6 mm. longis, tubulosis, hispidulis, dentibus lanceolato-linearibus, apice acuminatis, tubo aequilongis; corollis rubro-purpureis, 15 mm. longis, tubo multo exserto, arcuato, intus nudo, fauce dilatato, limbo parte tertia quam tubo breviore, labro integro, labiolo albido, rubro-punctato, appendiculis lateralibus nullis, antheris hirsutis; nuculis 1.5–2 mm. longis, albido-punctatis et colliculosis, oblongis, in basi hyalinis; gynobasi parva, lobo postice subnullo.

A cosmopolitan weed appearing particularly in waste ground along the margins of fields and in flat open places newly surfaced.

Specimens examined:

PERU: Oroya, 3076–4000 m., in moist soil, *Kalenborn 32* (US; MBG); Rio Blanco, half ascending in rock slides, May 8–19, 1922, *Macbride and Featherstone 673* (FM; MBG).

ECUADOR: Ambato, Tunguragua, Dec. 1918, *Pachano 67* (US).

CHILI: Santiago, Sept. 1, 1921, *Bro. Claude-Joseph 1355* (US).

LEONURUS L.

Herbae erectae, foliis maximam partem inciso-lobatis, inferioribus rotundatis, floralibus angustioribus, omnibus flores longe superantibus; floribus in verticillastris densis distinctis dispositis; bracteis subulatis; calycibus 5-venis, turbinatis, ore truncato, dentibus 5, apice subspinosis, demum patentibus; corollae tubo incluso vel rarius exserto, intus nudo vel oblique annulato, limbo bilabiato, labro oblongo, integro, in his speciebus subplano, in basi angustato, labiolo patente trifido, lobis lateralibus oblongis, medio obcordato vel subfurcato; staminibus e tubo exsertis, antheris per paria approximatis, bilocularibus, thecis parallelis transversalibus, valvulis nudis; stylo apice subaequaliter bifido, ramis subulatis; nuculis laevibus, triquetris, apice truncatis, angulis acutis.

1. **L. sibiricus** L. Sp. Pl. 584. 1753.

Herba erecta altitudine 40–60 cm., virgata vel ramosa, ramis lateralibus brevibus, glabra vel tenuiter pubescens, canaliculata, quadrata, angulis obtusis; foliis infimis rotundato-ovatis, subcordatis, obscure trilobatis, lobis irregulariter incisis, obtusis, mediis profunde trilobatis, lobis iterum incisis, frequenter subpedatis, superioribus subintegerrimis, omnibus ad petiolam longam attenuatis, subglabris, subtus pallidioribus, junioribus molliter pubescentibus, petiolis parte dimidia quam laminis brevioribus; floribus 8–25 in verticillastris densis, 1–1.5 cm. latis, infimis inter se distantibus 2–4 cm., superioribus approximatis; bracteis subulatis, 4–5 mm. longis, pubescentibus; calycibus 6–8 mm. longis, turbinatis, 5-venis, molliter pubescentibus, dentibus subspinosis, subaequalibus vel duobus superioribus majoribus, ore obliquo; corollis rubris (pink-Pennell), 12–15 mm. longis, pubescentibus, tubo e calyce paulo exserto, nectarostegio e pilis brevibus supra basim 2 mm. oblique annulato, limbo 6–7 mm. longo, labro oblongo, integro, labiolo oblongo, trifido, lobis lateralibus ovatis, medio majore, 5–6 mm. lato, obcordato vel subfurcato; staminibus didymis ad faucem sitis sub galea adscendentibus, filamentis ad basim glandulosis; nuculis 2 mm. longis.

Specimens examined:

Colombia: Cartagena, 1919, *Bro. Heriberto 240* (US); Trasquillo on Rio Sinu, grove along river in valley, 90–120 m., corolla pink, March 5–6, 1918, *Pennell 4611* (US; GH).

Venezuela: Lower Orinoco, Sacupana, April, 1896, *Rusby & Squires 25* (US; MBG; GH); Tovar, 1854–5, *Fendler 887* (MBG; GH); Caracas, March 14, 1899, *Moore 2* (GH).

Brit. Guiana: coast lands, June, 1889, *Jenman 5391* (US).

Brazil: *Glaziou* (US); Rio de Janeiro, *Martius 864* (MBG; GH); Rio de Janeiro, *Wilkes Exp.* (US).

Paraguay: Central Paraguay, 1888–90, *Morong 769* (US; MBG; GH); in region of Alto Paraná R., 1909–10, *Fiebrig 5369* (US; GH).

Argentina: Sta. Iquazu, Nov. 17, 1910, *Rodriguez 445* (US).

Leonotis R. Br.

Herbae fruticesve foliis variis, verticillastris densis, multifloribus; bracteis subulatis, numerosis; calycibus ovato-tubulosis, 10-venis, apice incurvis, ore obliquo sub-10-dentato, dente supremo majore; corollis speciosis, coccineis vel flavescentibus, patente villosis, tubo saepius exserto, intus nudo vel incomplete annulato, limbo bilabiato, labro concavo, erecto, integro, labiolo brevi patente trifido, lobo medio vix majore; staminibus sub galea adscendentibus, filamentis in basi inappendiculatis; antheris per paria sub labro approximatis, bilocularibus, loculis divaricatis, acutis; stylo lobo superiore brevissimo; nuculis apice obtusis.

1. **L. nepetaefolia** (L.) R. Br. Prodromus, 504. 1810.

Herba erecta altitudine 50–200 cm., virgata vel ramosa, ramis lateralibus brevibus, puberula, canaliculata, quadrata, angulis obtusis; foliis late ovatis, 3–10 cm. longis, maximam partem 5–7 cm., membranaceis, obtusis sed tamen apice leviter angustatis, subcordatis vel truncatis et ad petiolam abrupte angustatis, inciso-crenatis, crenarum culminibus 2–5 mm. altis, obtusissimis, inter se 2–5 mm. distantibus, utrinque viridibus, tenuiter cano-tomentosis vel glabris, floralibus oblongo-lanceolatis, petiolis gracilibus, longitudine foliorum aequilongis; verticillastris paucis, distantibus, globosis, saepe ultra 100-floribus, maturis frequenter 6–7 mm. latis; bracteis linearibus calycibus aequilongis, apice spinescentibus; calycibus tubulosis 12 mm. longis, maturis 20–25 mm., pubescentibus, in basi attenuatis, apice abrupte incurvis, ore obliquo, maturo clauso, dentibus 8, supremo maximo, acuto, spinoso, tribus inferioribus lanceolatis, aequilongis, acutissimis, rigidis, subreflexo-patentibus, lateralibus utrinque 2 (3), brevibus, acutis, erectis; corollis coccineis, 20–25 mm. longis, tubo paulo exserto, paulo dilatato, nectarostegio e pilis densis incomplete 1–3 annulato ad tubi medium sito, limbo tubo aequilongo, labro oblongo, 8–12 mm., integro, extus dense villosis, concavo, labiolo 4–5 mm. longo, glabro, mox marcescente, trifido, lobis oblongis, medio vix laterales superantibus; staminibus in galea inclusis, antheris divaricatis; stylo glabro, breve exserto, ramo superiore .5 mm. longo,

inferiore 3 mm.; nuculis oblongis 2.5–3 mm., gynobasis lobo postico sub anthesi elongato.

Specimens examined:

COLOMBIA: Cartagena, 1919, *Bro. Heriberto 155* (US); thickets on slopes east of Viterbo, 1100–1300 m., Sept. 4, 1922, *Pennell 10260* (ASP); Colé, Cauca, 1000–1200 m., Dec. 1905, *Pittier 631* (US); Dagua, El Valle, Dagua Valley, 700–900 m., May 13, 14, 1922, *Pennell 5630* (US; ASP).

VENEZUELA: Cristobal Colon, pasture, Jan. 5–Feb. 22, 1923, *Broadway 146* (US; GH); Tovar, 1854–5, *Fendler 894* (MBG; GH); Island of Margarita, El Valle, July 19, 1901, *Miller 74* (US; MBG; GH); Caracas, 800–1200 m., Apr. 8, 1913, *Pittier 6028* (US; GH).

BRIT. GUIANA: Vreed-en-Hoop, west bank of Demerara R., opposite Georgetown, wasteland along railroads, Nov. 10–12, 1919, *Hitchcock 16712* (US; GH).

BRAZIL: Bahia, *Salzmann* (MBG); Rio de Janeiro, 1837, *Tweedie* (GH); Porto Dom Pedro II, *Dusèn 880* (MBG).

PARAGUAY: Cordillera de Altos, Dec. 1902, *Fiebrig 584* (GH); Central P. in regione lacus Upacaray, Oct. 1913, *Hassler 12315* (US; GH; MBG).

ARGENTINA: Buenos Aires, Posadas, Feb. 20, 1914, *Vattuone & Bianchi 39* (US); Mendoza, *Gillies* (GH).

Explanation of Plate

PLATE 8

Teucrium cubense Jacq. subsp. *cordobense* Epling

Argentina

From the type specimen, *Kuntze,* in the United States National Herbarium.

EPLING—SOUTH AMERICAN LABIATAE

Explanation of Plate

PLATE 9

Teucrium tenuipes Epling

Galapagos Islands

From the type specimen, *Stewart 3342,* in the United States National Herbarium (drawing inverted).

EPLING—SOUTH AMERICAN LABIATAE

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COLLOIDAL SULPHUR AS A SPRAY MATERIAL

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In a recent study on the toxic property of sulphur it was found that sulphur became toxic to fungi primarily after it had been oxidized into the somewhat unstable compound, pentathionic acid. This compound is most stable and very highly toxic to fungi at a hydrogen-ion concentration of P_H 4.2–5.4. It was further found that the more finely divided sulphurs, and especially the precipitated forms, were more easily oxidized and were therefore more active as fungicides at temperatures and conditions at which the flowers, or flour, of sulphur exhibited toxicity to only a very slight degree.

Since these findings with reference to conditions favorable for toxic action were not in accord with conditions existing in most of the generally used sulphur sprays, it was thought advisable to test the comparative value of representative sprays in a commercial way. The need for a more active sulphur summer spray is urgent, in that lime-sulphur, because of foliage injury, is so frequently unsafe even on apple; likewise unsafe to a much greater degree on peach and cherry; and cannot be used at all on many of the smaller fruits. The other sulphurs, such as the various dusts, the dry mix and wettable sulphur, etc., are not sufficiently active to control fungi under all conditions. This lack of adequate control in all seasons is true of apple scab, a disease that is, however, ordinarily controlled with most of the sulphur sprays. In the case of blotch or bitter rot, the sulphur sprays are generally reported as ineffective. Com-

mercially, the spraying program for any one disease is expensive and may become considerably more so when several diseases in which the requirements are different are to be controlled.

It was hoped that a sulphur spray could be developed that would not only control apple diseases but would also be effective on other types of fruit and vegetables.

Preparation of Materials

Two types of colloidal sulphur were prepared. An attempt was made at the outset to prepare the materials by the method recorded in the previous report.[1] Because of the lack of apparatus many changes had to be made. The precipitated sulphur was prepared as follows: Ten gallons of lime-sulphur, 32° Baumé, were placed in a 50-gallon barrel. To this were added 10 gallons of water and 1 pound of glue previously dissolved in hot water. Sulphuric acid diluted with 3 parts of water was then added until the reaction of the mixture was P_H 4.2. The mixture was allowed to settle and the supernatant liquid decanted off. The residue, having the consistency of cream, contained 1 pound of active sulphur to the gallon and was used as a spray by adding 5 gallons of the precipitate to 95 gallons of water.

Considerable difficulty was encountered in the preparation of the colloidal soluble sulphur. Fifteen gallons of a saturated solution of sodium thiosulphate (hypo) were slowly stirred into 5 gallons of concentrated H_2SO_4, using a wooden barrel as a container. At this point the mixture should have been centrifuged, but no centrifuge of sufficient size was at hand. An attempt was next made to neutralize the mixture with NaOH and then to use it directly. In this way all of the soluble compounds were retained in the mixture, resulting in considerable burning when applied to foliage. Moreover, the high concentration of electrolytes precipitated most of the soluble sulphur.

Later in the season the mixture of hypo and acid was filtered through a fine screen and the filtrate neutralized with lime-

[1] Young, H. C. The toxic property of sulphur. Ann. Mo. Bot. Gard. **9**: 403–435. 1922.

sulphur diluted 1 to 3. During the addition of the lime-sulphur, which was slowly effected, a further quantity, 3 gallons, of concentrated hypo was introduced. By the addition of lime-sulphur, hydrogen sulphide fumes evolved, while SO_2 was produced by introducing hypo at the same time. When these two gases meet, soluble colloidal sulphur is formed, provided the sulphur dioxide is in excess. This latter condition was maintained. This method gave a very concentrated solution of soluble sulphur and should have been an excellent spray material had it been possible to have centrifuged it. For the same reason as stated above, the soluble sulphur was soon precipitated. Analysis showed that one gallon of the final mixture contained 10 ounces of active sulphur.

Plan of Experiment

In order to test the new material under as many conditions as possible and to be reasonably certain that diseases would appear in one or more locations, the experiments were tried in 5 states, namely, New York, Pennsylvania, Michigan, Illinois, and Virginia. In all of these states apple scab is frequently prevalent. Except in New York State the spray was applied only to apple. The materials were prepared at the New York Agricultural Experiment Station and then shipped to the cooperating stations. The spraying tests at the New York station were incorporated into the spraying program of the Department of Entomology. The 2 colloidal sulphur preparations were used in 3 Greening orchards and in one orchard of the Rome variety. Five regular applications were made, namely, the delayed dormant, the pink, calyx, 2 weeks, and early August. In the same orchards, tests were made of lime-sulphur 1 to 40 plain, also with glue, with casein, sulphur glue (8–4–50 formula), sulphur casein spray (8–4–50 formula), sulphur lead arsenate dust (90–10 formula), sulphur lead arsenate dust (90–10 formula) with glue and casein sticker, sublimed sulphur (16 pounds) with casein spreader, the same with 16 pounds of lime and casein spreader, ground sulphur with casein spreader, the same with 16 pounds of lime added, 85–15 dust, and the copper sprays, as listed in table I. The colloidal and precipitated mixtures con-

tained 5 pounds of sulphur per 100 gallons of spray and applied at the rate of 8 to 12 gallons per tree on blocks of 10 trees each. Sulphur dusts were applied at the rate of 5 pounds per tree and the copper dusts 4 pounds per tree.

On July 18, leaf counts were made on the Rome orchard, Geneva, New York. The results are tabulated in table I. Some of the check trees of this orchard were covered with a canvas during the spraying operation and all the trees used for checks had been checks for several years. This rather abnormal treatment of the checks may have resulted in the heavy initial infection. Counts were also made in two near-by test orchards of the Greening variety, the results of which showed practically no disease on the treated plots and less than two per cent on the check. Later in the season scab became more general on the Greening checks. From all indications the initial infection was not heavy, and a rather mild secondary infection occurred. In the main, scab was not difficult to control in the vicinity of Geneva, during the season.

TABLE I

RESULTS OF LEAF COUNTS ON THE ROME ORCHARD, N. Y. AGR. EXP. STA., GENEVA, MADE JULY 18, 1923

Plot	Treatment	No. of trees	No. of leaves counted	Per cent infection
1	Lime-sulphur	5	2500	.68
2	Lime-sulphur & Ca casenate	5	2500	.36
3	Sulphur & glue (8–4–50)	5	2500	2.5
4	Sulphur & casein (8–4–50)	5	2500	6.5
5	Colloidal sulphur	5	2500	.16
6	Check, trees covered	2	1000	98.
7	Check, trees uncovered	2	1000	90.
8	90–10 dust	5	2500	7.1
9	90–10 dust & glue sticker	5	2500	6.1
10	90–10 dust & casein sticker	5	2500	5.4
11	Precipitated sulphur	3	1500	4.2
18	Special process sulphur	2	1000	40.

At harvest time all the fruit in all of the plots was counted and a summary of results is given in table II. A more detailed account of all the tests is given in the report of the Department of Entomology, New York Agricultural Experiment Station, Geneva, New York.

TABLE II

COLLOIDAL AND PRECIPITATED SULPHUR COMPARED WITH OTHER SPRAYS IN NEW YORK STATE

	No.	Treatment	No. of trees examined	Aver. no. apples per tree	Aver. no. scabby apples per tree	Per cent scabby apples	Per cent clean fruit
Hall Orchard, Greening	1	Spray, lime-sulphur.....	17	1683	11.4	1.18	88
	5	Spray, sublimed sulphur, 8 lb................	10	1415	29.5	2.08	
	6	Spray, sublimed sulphur, 8 lb., 8 lb. lime......	9	2265	46.	2.02	
	7	Spray, precipitated sulphur...............	6	1932	14.	.72	96
	8	Spray, colloidal sulphur.	6	1924	28.	1.45	91
	9	Spray, flour sulphur, 16 lb.	9	2388	34.	1.43	
	10	Spray, flour sulphur, 16 lb., 8 lb. lime........	10	1651	32.2	1.95	
	11	Spray, flour sulphur, 8 lb.	7	3486	50.3	1.44	
	12	Spray, flour sulphur, 8 lb., 8 lb. lime........	9	1895	74.7	3.94	
	13	Dust, 90–10, 5 lb. per tree	9	1143	19.0	1.65	
	15	Dust, 85–15, 5 lb. per tree	8	1287	7.	.53	
	17	Dust, 77–13–10 lime copper, 4 lb. per tree.....	10	1846	224.8	12.17	
	21	Dust, copper arsenate lime................	10	1127	213.	18.89	54
	22	Check, no treatment....	5	849	736.	86.81	5
	23	Check, 1 application besides lime-sulphur, lead arsenate, nicotine at calyx..............	5	1474	334	22.68	36
Black Orchard	1	Lime-sulphur........	1	1284		2.3	86.6
	4	Precipitated sulphur	1	2080		1.8	96.3
	5	Wettable sulphur & glue	1	2234		3.6	91.7
	6	Colloidal sulphur.......	1	1153		1.6	95.0
	7	Check	2	1098		84.8	
North Rose Orchard	1	Dust 90–10...........	4			5.0	
	4	Wettable sulphur......	4			4.8	
	7	Dust, dehydrated copper sulphate...........	4			19.75	
	8	Colloidal sulphur	4			4.0	
	6	Check................	6			83.07	
Rome Orchard	1	Lime-sulphur..........	5			1.7	
	3	Wettable sulphur......	5			7.6	
	5	Colloidal sulphur.......	5			5.9	
	8	90–10 dust...........	5			4.6	
	11	Precipitated...........	2			2.2	
	6	Check................	3			90.7	

Spray injury was also noted on all the sprayed plots. The most severe burning resulted from the lime-sulphur spray.

Occasionally some burning was noted with colloidal sulphur. The copper sprays caused some leaf burning and an immense amount of russeting of fruit. In general, leaves sprayed with precipitated sulphur appeared best throughout the season. A more detailed discussion of spray injury is given by Young and Walton.[1]

The material sent to Michigan was applied by Professor W. C. Dutton of the Department of Horticulture. A late frost caused all the fruit to drop so that the experiment was discontinued after the second application.

In Pennsylvania the materials were applied by Mr. R. C. Walton, of the Department of Plant Pathology, Pennsylvania State College. The tests were conducted on Stayman Winesap apples in orchards owned by Mr. Eshelman and Mr. Keller. Precipitated and colloidal sulphur, commercial lime-sulphur (1 to 40) with and without arsenate of lead, dry mix, and sulphur dust were used. The sprays were applied with a 300-gallon power sprayer equipped with 2 guns and giving a pressure of 250 pounds. In 1922 the trees were seriously affected with scab.

The delayed dormant spray was entirely of lime-sulphur and applied April 18, when the first leaves were showing approximately ¼ inch but had not started to spread. The "pink" application was made April 30, at which time about $^1/_5$ to $^1/_4$ of the central buds were opening and the stems had separated. On May 11 the "petal fall" application was made, when practically all the petals had fallen. The 10-day application was made May 22. On May 23 very little scab could be found, not even on the check plots. Scab began to show on the check plot to a considerable extent on June 4, but was not serious. The weather, prior to the opening of the blossoms, was very dry. The rains were few and light, and conditions in general were unfavorable for scab development. A 4- to 5-week spray was applied June 20, and the late summer spray, August 6.

During the 4- to 5-week spray the temperature was 100° F. in the shade. The lime-sulphur burned severely, and traces of burning were noticed in the precipitated and dry-mix plots. On August 6 the check trees were heavily infected with scab on both fruit and foliage.

[1] Young, H. C. and R. C. Walton. Spray injury to apples. Phytopath. **15:** 405–416. *pl. 14. f. 1.* 1925.

TABLE III

KELLER STAYMAN WINESAP ORCHARD, ARENDTSVILLE, PENNSYLVANIA

Plot No.	Treatment	Applications		Per cent scab				% fruit spot	% sooty blotch	% side scald	No. fruit	% unsound	Red bug	Aphis	Codling moth	Leaf roller	Tree cricket
		No.	Time	Slight	Mod.	Sev.	Total										
1	Precipitated sulphur	5	Apr. 20 Apr. 28 May 1 May 11 May 23 Aug. 3	4.1	.4	.4	4.9	17.6	4.7	.1	1086	11.2	1.3	2.3	.9	7.1	
2	Dry-mix	5	Ditto	6.6	.9	.4	7.9	17.2	5.1	.6	1052	9.4	.7	2.7	.1	5.6	
3	Colloidal sulphur........	5	Ditto	4.02	.59	.48	5.09	17.92	21.84		1176	19.0	8.2	3.4	1.2	6.3	
5	Lime-sulphur	5	Ditto	.1		.2	.3	12.1	.7	.9	1035	11.4	.2	2.1	2.2	8.6	
7	Check—No treatment			54.6	24.4	15.8	94.8	67.6	72.8		1023	66.3	33.6	10.4	5.8	17.7	21.1

S. C. ESHELMAN STAYMAN WINESAP ORCHARD, ARENDTSVILLE, PENNSYLVANIA

Plot No.	Treatment	No.	Time	Slight	Mod.	Sev.	Total	% fruit spot	% sooty blotch	% side scald	No. fruit	% unsound	Red bug	Aphis	Codling moth	Leaf roller	Tree cricket
5	Precipitated	6	Apr. 18 30 May 11 -12 May 22 June 20 Aug. 6	3.3	.7	.2	4.2	3.1	.2	1.6	1202	12.4	1.9	6.3	.2	5.2	
6a	Lime-sulphur—No lead until June 20	6	Ditto	1.9	.6	.2	2.7	1.1	.8	5.8	1260	22.3	4.5	8.2	.6	11.2	
6b	Lime-sulphur—Ars. lead ...	6	Ditto	3.1	.8	.3	4.2	1.1	.3	6.6	1059	22.0	6.5	10.7	.5	5.9	
7	Dry-Mix	6	Ditto	7.5	2.2	.6	10.3	2.6	.6	2.7	906	21.8	4.9	12.6	.1	4.4	
8	Check—No treatment...			51.54	16.81	13.16	18.51	13.72	9.8		641	25.4	8.7	6.0	1.7	9.2	
9	90-10 Dust	9	May 2 May 5 May 15 May 18 May 24 June 6 June 16 July 17 Aug. —	11.27	.58	1.73	13.58	5.49	4.62		347	15.5	1.7	8.6	1.1	3.8	

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Plot No.	Treatment	Applications		Per cent scab				% fruit spot	% sooty blotch	% side scald	No. fruit	% unsound	Red bug	Aphis	Codling moth	Leaf roller	Tree cricket
		No.	Time	Slight	Mod.	Sev.	Total										
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S. C. ESHELMAN STAYMAN WINESAP ORCHARD, ARENDTSVILLE, PENNSYLVANIA																	
5	Precipitated	6	Apr. 18 30 May 11 -12 May 22 June 20 Aug. 6	3.3	.7	.2	4.2	3.1	.2	1.6	1202	12.4	1.9	6.3	.2	5.2	
6a	Lime-sulphur—No lead until June 20	6	Ditto	1.9	.6	.2	2.7	1.1	.8	5.8	1260	22.3	4.5	8.2	.6	11.2	
6b	Lime-sulphur—Ars. lead ...	6	Ditto	3.1	.8	.3	4.2	1.1	.3	6.6	1059	22.0	6.5	10.7	.5	5.9	
7	Dry-Mix	6	Ditto	7.5	2.2	.6	10.3	2.6	.6	2.7	906	21.8	4.9	12.6	.1	4.4	
8	Check—No treatment...			51.54	16.81	13.16	18.51	13.72	9.8		641	25.4	8.7	6.0	1.7	9.2	
9	90-10 Dust	9	May 2 May 5 May 15 May 18 May 24 June 6 June 16 July 17 Aug. —	11.27	.58	1.73	13.58	5.49	4.62		347	15.5	1.7	8.6	1.1	3.8	

Tests including both the precipitated and colloidal sulphur were made in the Keller Stayman Winesap orchard. The spray schedule was practically the same for each test. On August 3 the fruit on the "precipitated" plot appeared very fine and the owners were very much pleased with the spray. Observations made on September 28 indicated that the fruit sprayed with precipitated sulphur, colloidal sulphur, and dry-mix sulphur was more highly colored than that sprayed with lime-sulphur. The results from both orchards are given in table III.

The Illinois tests were conducted by Dr. H. W. Anderson, of the Department of Horticulture, University of Illinois. In his orchards scab did not show to any extent on the check trees. He states that neither the precipitated nor colloidal sulphur controlled blotch. Where the checks showed 98 per cent blotched apples, the precipitated sulphur gave 48.4 per cent and the colloidal 70 per cent. Lime-sulphur gave 26 per cent. A more complete report of these tests was given by Dr. Anderson at a meeting of the Illinois State Horticultural Society in December.

The experiments in Virginia were conducted by Professor Schneiderhahn at Winchester. He reported that owing to the dry season no disease developed on the check plots and he therefore obtained no check on the material. He stated further that he has never observed before such a striking correlation between climatic factors and disease prevalence as exists in this section, and also: "that in spite of the fact that the trees in these plots received approximately 14 gallons of spray material per tree, there was no perceptible spray burn on leaves or fruit and the variety is the Ben Davis,—the most susceptible to spray burning. I am convinced that there is very little, if any, danger from spray burning with the materials you sent me. We have had exceptionally hot weather and the leaves of these trees were nearly white after the spray dried, but no damage resulted."

Discussion of Results

In general the past season cannot be considered one favorable for scab development, especially in Illinois and Virginia. Since nearly every type of sulphur spray gave commercial control of

scab, it might be said that climatic conditions favored the toxic action of sulphur. The dry and warm season in both New York and Pennsylvania undoubtedly increased the action of sulphur.

Because of the type of season it is difficult to draw very definite conclusions as to the value of one sulphur spray over another. In the main, however, the precipitated sulphur was not quite as effective as lime-sulphur, but more effective than the dusts, dry mix, or wettable sulphur. Its value was greater than lime-sulphur because in most every case no injury to foliage resulted and in every case a higher percentage of clean fruit was obtained. In New York, Pennsylvania, and Virginia, the growers in whose orchards precipitated sulphur was used were very well pleased with it. Whether it would be as effective in a season more favorable for scab development, is a question that can be answered only by further trials. The materials, both colloidal and precipitated sulphur, could not be prepared as desired, because of the lack of equipment, and it is thought that both forms would be considerably more active and injury to foliage less if better purification methods could be employed.

Since precipitated sulphur caused practically no injury to apple foliage, it was thought advisable to try it on other fruits, using the same concentration as for apples, namely, 5 gallons of the concentrated in 100 gallons of spray. Trees of two-year-old peaches were sprayed heavily. The peach trees were in a rapidly growing condition and therefore in a succulent state when they are more susceptible to injury. They were sprayed July 24, during a spell of warm weather. Careful observations were made daily for 14 days, during which time no leaves that showed spray injury could be found.

A similar experiment using colloidal sulphur was conducted at the same time. There resulted in this case considerable burning but not enough to be of economic importance. These tests were continued until August 30, during which time the applications of colloidal sulphur resulted in injury.

Both materials were tried on sweet and sour cherries, grapes and plums. Slight injury was noted on the foliage of cherry

and severe burning on grapes where the colloidal sulphur was used, but no injury whatever with the precipitated sulphur. The injury caused by the colloidal sulphur was undoubtedly due to the soluble sodium salts that it contained.

During the summer, colloidal sulphur preparations sent to us from the Texas Gulf Sulphur Company and the Riches-Piver Company were sprayed on peaches of the same type and conditions as mentioned above. No foliage injury resulted from either compound. Both types spread and stuck very well. In one case at the times of application, about 3 P. M. and about 5 P. M., it began to storm and rain and continued intermittently until morning. The following day the trees showed white and very little of the spray had been washed off. The precipitated sulphur was used in this same experiment and very little remained on the trees. The Texas Gulf Sulphur Company product had a hydrogen-ion concentration of 7.4, that of the Riches-Piver 4.2. No test could be made at that time as to the fungicidal value of the two products. The Herbert and Herbert product was received too late for outside tests.

One of the most serious defects in both the precipitated and colloidal sulphur was their sticking quality. The quantities of $CaSO_4$ and other coarse insoluble matter prevented their close adherence to the leaf surface. When prepared in a pure state both compounds stick very well, the colloidal especially. The sticker casein could not be used because of its reaction. Late in the season Professor Dutton, of Michigan Agricultural College, called my attention to semi-solid buttermilk as prepared by the Consolidated Products Co., of Chicago, Ill. This company kindly sent me a gallon of the product. This amount was added to 50 gallons of spray mixture of precipitated sulphur. This mixture was applied to peach trees, and stuck and spread very well. The reaction of the mixture was not altered.

The possibility of having a general sulphur spray that can be used on all fruits seems certain, especially in districts where blotch and blister rot are not present. My products, prepared in the manner they were, were for my own satisfaction, and there is little doubt in my mind but that the commercia, products listed above will prove to be more active fungicidallyl providing their reaction point be near P_H 4.2–5.0.

The work here reported represents some practical applications of the sulphur project which has been pursued at the Missouri Botanical Garden. The writer is greatly indebted to the New York Agricultural Experiment Station, Geneva, and thanks are due the members of the Department of Entomology for their hearty cooperation, and especially to Mr. P. J. Parrott, for making available facilities for work, and to Mr. G. P. MacLeod for assistance in the preparation of materials. Thanks are also extended to the cooperators mentioned in the text and to the Crop Protection Institute, under whose auspices the work was done.

PIGMENT STUDIES WITH SPECIAL REFERENCE TO CAROTINOIDS IN FRUITS[1]

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This investigation, concerned primarily with the carotinoids, has been divided into 4 sections, as follows: (1) plastid studies; (2) the use of the colorimeter in the determinations of relative amounts of fruit pigment; (3) determinations of the presence of certain pigments in various fruits; (4) ripening experiments. These sections will be discussed in the order indicated.

Plastid Studies

INTRODUCTION

The problem of the origin and structure of leucoplasts, chloroplasts, and chromoplasts has occupied investigators for many years. The state in which the carotinoid pigments occur in fruits, flowers, and leaves has been much under discussion. Are these carotinoids in crystalline or granular form and more or less free in the cell cytoplasm, or are they necessarily imbedded in lipoid material and usually contained within a stroma or plastid? If, as some workers believe, chloroplastids are the progenitors of chromoplastids in which the carotinoid pigments must be contained, how are we to account for the presence of these pigments in the animal kingdom or in various groups of fungi in which chloroplasts are never present?

In an attempt to throw some light on these problems microscopic studies were made on plastids of green, yellow-orange, and red-ripe fruits. Fruits were chosen because the plastids are large and changes can be very easily noted during the ripening process. In several kinds of fruits the decolorization of the chromoplasts was accomplished, leaving behind a colorless stroma very similar to that of the chloroplast. During the in-

[1] An investigation carried out at the Missouri Botanical Garden in the Graduate Laboratory of the Henry Shaw School of Botany of Washington University, and submitted as a thesis in partial fulfilment of the requirements for the degree of doctor of philosophy in the Henry Shaw School of Botany of Washington University.

vestigation evidence was accumulated to show that in some fruits the carotinoids were in granular or crystalline form, while in others these pigments were contained in plastids commonly known as chromoplasts. No attempts were made to show just where the color was located in the plastid.

SURVEY OF LITERATURE

The earliest work on plastids was concerned especially with the study of starch grains. The investigations of von Mohl ('55), Böhm ('57), Nägeli ('58), and Sachs ('62) showed that starch grains appeared in a great many of the chloroplasts. More than 10 years before Schimper's experiments on plastids we have the first work along this line by Kraus ('72) who sought to show that the yellow color of the tomato and the rose was originally green, and that the yellow color originated from the green, also that the green chlorophyll-containing bodies, with or without a continuation of form, acquired a yellow color. He assumed that in this case the blue-green pigment disappeared and the original yellow remained or even increased in amount. Kraus was the first worker to prove that the yellow fruit pigments are identical with those of this class in the chloroplasts of the leaf.

Another of the early workers was Millardet ('76) who believed that the chlorophyll bodies became more or less deformed just prior to the disappearance of the chlorophyll. At the same time a great number of these bodies losing their coherence, became elongated and irregular, appearing separate and viscid. A little later they became swollen and coalesced to form somewhat irregular masses located in vacuoles of the cytoplasm. They assumed a more or less yellow-orange tint, due to the presence of small rods of "solanorubin." This colored substance was finely granulated but coarser than that of the chlorophyll. In a later stage these rods of solanorubin multiplied and increased in size.

Schimper ('83), in his epoch-making studies on the origin of plastids, concluded that all plastids arose from the division of preëxistent plastids, that they never arose *de novo* from the protoplasm. These plastids were then transmitted only in the female line, never through the sperm. He found chloroplasts in the embryos of a great many of the higher plants, such as *Hy-*

pericum, Tropaeolum, Evonymus, Helianthus, Acer, etc. Schimper showed that leucoplasts may be transformed into chloroplasts by the chlorophyll becoming photosynthetically active or they may remain as leucoplasts and serve in the building of starch from food already assimilated. Finally, in various parts of the plant, as, for example, in roots, leaves, flowers, and fruits, the chloroplasts may become transformed into chromoplasts of various shapes and diverse colors.

That chloroplasts arise from leucoplasts and chromoplasts from chloroplasts, was Schimper's view. He noted an exception to this in the fruit of *Symphoricarpus racemosus*, which, in the ripe condition, contained leucoplasts which were transformed chloroplasts. The latter phenomenon was found to occur in many embryos. This writer assumed that the chloroplast, or the photosynthetic chromatophore, is the most primitive of the 3 types of plastids. From the phylogenetic point of view the leucoplast and chromoplast represented later development and arose concurrently with an increase in tissue differentiation.

Meyer ('83) substantiated much of this work of Schimper's, so that often the theory of the origin of plastids from preëxistent plastids is known as the Schimper-Meyer theory. This theory of Schimper and Meyer has never been seriously called into question in the higher cryptogams nor in the algae, but in phanerogams it has caused some discussion. Mikosch ('85) and Belzung ('87) could find no chromatophores in the resting seeds which they investigated. After examining ripening seeds, mature seeds, and seedlings of a large number of plants they concluded that growth of starch grains can take place without leucoplasts and that chloroplasts are formed directly by differentiation of the cytoplasm.

Courchet ('88) decided that "chloroleucites" and most of the "chromoleucites" have an analogous structure. They consist of a protein substratum or stroma in which are enclosed granules either of chlorophyll or other pigments. Rarely, these pigments are truly crystalline in nature. He believed with Schimper that the "leucites" always resulted from the division of preëxisting leucites and that they multiplied by direct division. Frequently the chromoleucites arose independently of the colorless leuco-

leucites. He studied many different flowers and fruits, among them the flowers of *Aloe* and the fruits of *Evonymus japonicus* (arils) and *Cucumis Citrullus*.

Another worker to substantiate the Schimper-Meyer theory of the origin of plastids was Chmielevsky ('90), who showed that in *Spirogyra* the chromatophores of the male cell disappeared at the time of cell conjugation, while those of the female cell divided and gave rise to the chromatophores of the new plant. Davis ('99) observed the division of a chloroplast in a spore mother cell of *Anthoceros*. Zimmermann ('94), who worked primarily on algae but also on ferns, discussed the chemical and physical character of the chromatophore pigments. His views regarding the development of plastids were the same as Schimper's.

Lotsy ('07) claimed that the Schimper-Meyer theory was not sustained by sufficient evidence so far as higher plants are concerned. He suggested that if hybrids could be obtained between species with markedly different chromatophores, it might be shown experimentally that chromatophores were transmitted only in the female line. Senn ('08), in his extensive work on the form and change of position of chromatophores, studied a great many different algae, also the leaves and stems of spermatophytes, but no fruits were investigated by him. He found that chromatophores change form and position in response to light, temperature, water content, also chemical and mechanical influences. He observed protoplasmic connections between plastids.

Sapehin ('11) observed that during sporogenesis in mosses each archegonial cell contained 1 or 2 deeply staining bodies lying close to the nucleus; these he considered to be chloroplasts. A similar condition existed in *Anthoceros*. All the other Bryophytes and Pteridophytes as well as the Spermatophytes examined showed a considerable number of plastids in the archegonial cells. He traced the division of the single chloroplast in the spore mother cell of various mosses into 4, one going into each tetrad. The ripe spore was found to contain several chloroplasts, as did all the cells of the gametophyte and of the embryo sporophyte. Sapehin ('13), working with *Lycopodium*, showed that each cell of the young antheridium contained numerous plastids, but the number is reduced to one in the antherozoid mother cells. This work is

very important as a substantiation of the Schimper-Meyer theory, for it has sustained the idea of complete genetic continuity of the plastids throughout the life cycle in various groups.

Rothert ('12), in an extensive study of various vegetable organs from many different plants, examined and described carefully the form and shape of the plastids. He found the pigment, whether yellow, orange, red, or brown, to be in distinct granular form, distributed in the stroma, probably dissolved in drops of oil. In one plant, a saprophytic orchid, the pigment was observed to exist as needle-shaped crystals. He believed that chloroplasts and chromoplasts contained the same pigments but in quantitatively different proportions. The carotin was present in distinct grains but the chlorophyll was distributed evenly in the stroma, the latter often colorless but sometimes pale green. His views on the origin of plastids were very similar to those of Schimper, that is, that they form an unbroken series. Molisch ('13) believed that leucoplasts and chloroplasts may be transformed one into the other, and that chromoplasts may be finally produced from chloroplasts.

No review of literature on the subject of plastids would be complete without some mention of mitochondria or chondriosomes, employing these terms as synonymous. An enormous literature has accumulated on the subject, both from the animal and plant side. Only one phase of it will be given here, namely, that which has to do with the theory that mitochondria are the progenitors of plastids. A very good general review and bibliography of the subject was given by Cavers ('14), and likewise by Sharp ('21). Among those who claim mitochondria to be the progenitors of plastids Lewitsky ('10) stands out as one of the most important of the early workers. He found these bodies present in all essential parts of the cytoplasm, not only in the pollen mother cells but also in the pollen grains of *Asparagus officinalis*. In the stem end of the embryo, the chondriosomes changed to chloroplasts; on the other hand, in the root end they were transformed to leucoplasts.

This work on mitochondria, so contrary to the ideas of Schimper and Meyer, was criticized by the latter (Meyer, '11), on the ground that if such bodies really existed, it was extraordinary

that he and Schimper should have overlooked them. Rudolph ('12) obtained no evidence of any relation between chondriosomes and chloroplasts. He worked with a large number of plants belonging to various groups, using the Benda killing method and iron-haematoxylin stain with best success. He concluded from his results that the value of all previous work was merely to show the existence of such bodies in many different plants. Mottier ('18) was also unable to confirm Schimper's view, in a study of the root-tips of *Pisum sativum* and *Zea Mays*, of the thallus cells of *Marchantia* and of *Anthoceros*, and cells of the stems and leaves of *Elodea canadensis*. In this work he found cells containing both chloroplasts and chondriosomes, and his conclusions were that the primordia of leucoplasts were not the so-called mitochondria. He observed other granular bodies that did not become leucoplasts; these he considered mitochondria whose function could not then be definitely formulated. He suggested that perhaps these last are concerned in some processes of metabolism. Twiss ('19), working with *Zea Mays* and *Preissia*, was able to show an unbroken series from mitochondria to plastids in the root-tips of corn, while in *Preissia* this seriation was not so obvious However, he believed that such definitely staining bodies as mitochondria exist as normal constituents of the protoplasm.

Guilliermond has produced more evidence than any other worker to show that mitochondria are progenitors of plastids. He has published a number of papers, only a few of which can be reviewed here. In an important work (Guilliermond, '13) he described the occurrence of chondriosomes in the young asci of *Pustularia vesiculosa*, in *Penicillium*, *Botrytis*, *Endomyces*, yeasts, and in various *Autobasidiomycetes*. In a later paper of the same year he found chondriosomes in a number of *Pezizeae*. This was especially interesting since these forms contain an abundance of carotinoids. In *Pustularia* he distinguished 3 kinds of reserve substances, glycogen, fat, and the so-called "metachromatic corpuscles" of earlier writers. He claims to show that the latter arise from chondriosomes in much the same way as do the plastids of higher plants. His paper (Guilliermond, '19) records the results of his extensive studies on the epidermal cells of the petals of several different flowers, such as tulip and

iris, and also the mesophyll cells of several fruits including the berry of *Asparagus*. He observed the shape, form, movement, and division of chondriosomes of living material in isotonic solutions, and also studied material fixed by Benda's method and stained with iron-haematoxylin. A detailed explanation was given of just how the different plastids were formed from the chondriosomes. He argued that Schimper's so-called protein crystalloids were only the long-drawn-out ends of the dividing chondriocontes. Upon examination they showed no optical properties. In a later paper (Guilliermond, '21), he described the origin of leucoplasts from their primordia in root-tips of castor bean, bean, pea, corn, and a gourd. He acknowledged the fact already established by Rudolph, Sapehin, and Mottier that, besides the primordia of plastids, there may be other similar granules and rods present in a cell which do not become plastids. Kozlowski ('22), in a criticism, said that the whole subject of mitochondria was too indefinite and needed clearing up. He believed that a worker started with a preconceived idea of what chondriosomes should produce and then fitted them into his particular problem.

There has been a little work devoted especially to the formation of carotinoids. The Toblers ('10) made an extensive study of the nature and appearance of carotin in the fruit of *Momordica balsamina*. They found that after reaching maturity all parts of the pericarp quickly became green and showed rich starch content. In the layers of the mesocarp near to the fibro-vascular bundles and also in the endocarp, starch was especially abundant. As the fruit ripened there was a decrease in the amount of starch, and while the mesocarp was becoming yellow the endocarp was turning a light rose-red color, which constantly increased. In this region the deep red color of the aril finally became apparent. The orange-yellow color characteristic of the mesocarp was due to the presence of lens and needle-shaped crystals. In another piece of work finished in the same year the Toblers ('10a) concluded that, in the absence of more conclusive evidence, the idea of a direct genetic relation between chlorophyll and carotin must be excluded. Using the same fruit, *Momordica balsamina*, they decided that throughout the ripening process the formation of

carotin was connected with the decomposition of chlorophyll. They attempted to show a possible relation between carotin formation and the path of nutrition, since the basal part of the fruit always remained green longest. They showed that if respiration is prevented by covering the fruits with vaseline, the ripening process is retarded.

The same workers (Toblers, '12) made comparative researches on chlorophyll, carotin, starch, and sugar in 3 regions of the carrot, namely, top, middle, and base. They found the amount of carotin increased in indirect proportion to the chlorophyll but directly with the starch and sugar content. Age seems to determine the proportion of starch and sugar present and also the amount of carotin. In old roots both starch and carotin decreased from the top downwards, although in younger ones starch was in excess at the top. The sugar content always increased in all regions with age. The progressive greening marked the decrease of starch, the subsequent products of photosynthesis being stored as sugar. These workers observed that carotin is laid down in medullary rays. They remarked on the presence of carotin, often considered a decomposition product of chlorophyll, in close connection with such storage products as starch, sugar, and oil. They concluded that the relations which govern the appearance of carotin are very complicated.

Duggar ('13) during some microscopic observations on the formation of lycopersicin in tomato found that the development of this carotinoid is preceded by the paling and ultimate disappearance of the chlorophyll, and that following this change there occurred a yellowish or orange cast in the chloroplastids. With the disorganization of the chloroplast there appeared granules of an orange carotin-like pigment. Accompanying these changes typical lycopersicin crystals were formed, and as these increased there seemed to be a decrease in the number of orange granules or crystals.

Lubimenko ('14) believed that lycopersicin appears after the decomposition of the chlorophyll, and especially so in those organs which are characterized physiologically by very energetic oxidations in the tissues. Lycopersicin, however, does not exist within the chloroleucites of the fruit before the decomposition

of the chlorophyll. Later ('16) he found during the conversion of chloroplasts into chromoplasts that (1) chlorophyll and the accompanying pigments were decomposed; (2) yellow pigments accumulated and then (3) undergo alterations.

The decomposition of chlorophyll and the accompanying pigments was brought about by oxidations, with the accumulation of yellow pigments and of peroxidase, at the same time with an increase in acidity.

MATERIAL AND METHODS

Green, partly ripe, and fully ripe fruits of the following plants were used: *Solanum Lycopersicum* L., *Rosa rugosa* Thunb., *Asparagus officinalis* L., *Capsicum annuum* L., *Lycium halimifolium* Mill., *Aglaonema Treubii* Engl. Investigations were also made on the following: yellow and red stages of *Solanum Dulcamara* L. and *Solanum Pseudo-capsicum* L.; green and ripe fruit of *Sorbus sitchensis* (Roem.) Piper, and *Solanum carolinense* L.; red-ripe fruits of *Rhus canadensis* Marsh, *Arisaema triphyllum* (L.) Schott, *Citrullus vulgaris* Schrad., *Celastrus scandens* L. (arils), *Evonymus americana* L., *Evonymus europaea* L., *Lonicera* sp., *Viburnum Opulus* L., *Crataegus Phaenopyrum* (L. f.) Medic., and *Dracaena Godseffiana* Hort.

In studying the green fruits water mounts were made of free-hand sections, or in some cases strips of epidermis were used. The same method was followed with the partly ripe and fully ripe material when possible, but often the ripe fruits were too soft to permit of such treatment. Under these circumstances smears were made either of the mesocarp or of the juice alone. Many of these sections were very satisfactory for study without staining. However, to determine if chromoplasts of most fruits are really plastids, killing and staining were resorted to.

A variety of killing and staining methods was tried, but only some of the more satisfactory will be mentioned here. Free-hand sections were killed by a treatment of 30 minutes in stock chromo-acetic solution made up by Chamberlain's ('15) formula, washed in water for 1 hour, dehydrated in the usual grades of alcohol, stained for 3–10 minutes in 1 per cent erythrosin (made up in 70 per cent alcohol), run through the remaining alcohols to

xylol, and mounted in Canada balsam. A very satisfactory method for staining chromoplasts was to kill in medium chromo-acetic solution for 30 minutes, and then wash in water for 1 hour. The sections were then placed directly into an aqueous solution of 0.5 per cent acid fuchsin for 2–10 minutes, after which they were transferred direct to 95 per cent alcohol, dehydrated in the usual manner, and mounted in Canada balsam. This latter procedure was modified to great advantage by mounting in glycerine directly out of the stain. One of the most satisfactory methods for staining chromoplasts of juicy fruits was to press out on a slide first treated with albumin fixative a drop of the juice, which was almost certain to contain an abundance of the plastids, and these were allowed to dry 15–30 minutes. This material was then killed on the slide for 30 minutes in the stock chromo-acetic solution, washed for the same length of time, stained in acid fuchsin, and mounted in glycerine as indicated above.

Paraffin sections 10 μ thick were cut with a rotary microtome from material killed in stock chromo-acetic solution and stained in Haidenhain's iron-alum haematoxylin.

EXPERIMENTAL DATA AND DISCUSSION

The pepper fruit was studied in some detail. Spaces about 2 cm. in diameter were marked off on each of 3 peppers. These fruits were then placed in an electric oven at about 25° C. to ripen. The marked areas were examined during a period of 15 days while the fruits were ripening, at 5-day intervals. In all 3 peppers the results were approximately the same, so only one set of drawings was made. These were camera-lucida drawings of free-hand sections, mounted in water, showing the changes in shape of the plastids, during the various ripening stages (pl. 10, figs. 1–3). With the gradual change in color from green to yellow to orange, and then to the red-ripe pepper color there was a gradual elongation of the plastid and in some of the red-ripe chromoplasts the ends were actually pointed.

To determine whether the chromoplasts of red-ripe pepper were really plastids they were stained with iron-haematoxylin. Strips of the epicarp containing many chromoplasts were killed and stained in acid fuchsin by the method indicated above. The

results were very satisfactory, another proof of the fact that red pepper chromoplasts are really stainable bodies (pl. 10, figs. 4–5). The chromoplasts stained in this material were mostly of the elongated type. In fig. 4 the chromoplasts appeared to be in various stages of division, and a tendency for them to collect around the nucleus was observed.

Free-hand sections of green and yellow-orange tomatoes, mounted in water, showed up the plastids very well. In the green material the chloroplasts were of the ordinary shape; in the yellow-orange a number of pigment granules beside the plastids were visible, also a few small crystalline bodies. These pigment granules were carotin-like in color, while the crystals had rather a pinkish cast. The red-ripe fruit was very hard to section, and so smears were made. In these, beautiful carmine-red, needle-like crystals were observed. In addition, some granular pigment material was present, but no real plastids of any kind (pl. 11, figs. 1–3). Microtome sections made of the 3 stages of fruit and stained with iron-haematoxylin gave well-stained plastids of the green and yellow-orange fruit, but in the red-ripe fruit no plastids appeared, and the crystals seen in the fresh material had entirely disappeared, or were so distorted that they could not be recognized. Attempts were made to stain these needle crystals with acid fuchsin, but with no success, and indeed in the resulting slides no crystalline forms could be found.

Free-hand sections of all 3 stages of the rose fruit showed up the plastids very distinctly. In this fruit a very marked change in the shape of plastids occurred. In the yellow fruit they were elongated, in the red material much more so; in some cells they looked almost like long irregular streaks of colored oil. To get good results smears had to be made of the red-ripe fruit. Free-hand sections and smears of the green, yellow-orange, and red-ripe material were killed and stained in erythrosin as indicated above. The green and yellow-orange plastids stained very readily, but the red-ripe smears were not so satisfactory. It was very difficult to get slides in which the chromoplasts retained their exact shape during the staining process (pl. 10, figs. 6–8).

Green, yellow-orange, and red-ripe fruits of *Lycium* were studied by the free-hand sections mounted in water; here a

gradual elongation of the plastids was observed, but the red-ripe chromoplasts were not so markedly different as in some other fruits. Smears of the red-ripe fruit juice were very interesting; in these slides plastids of peculiar shape were observed, quite different from those of the mesocarp itself. There is a striking resemblance between these plastids and the chondriosomes of *Asparagus* as pictured by Guilliermond ('19), although the chondriosomes of Guilliermond are much smaller. Smears, also free-hand sections, of the red-ripe *Lycium* fruits killed and stained in acid fuchsin showed plastids of very much the same shape as those in the fresh material (pl. 12, figs. 1–5).

Great difficulties were experienced in attempts to make sections of green *Asparagus* fruits, this being due to a hard, bony epicarp. Smears of the mesocarp of fruits of 3 degrees of ripeness mounted in water showed up plastids very well. Here again the red-ripe chromoplasts were very unlike those of the green and yellow-orange preparations. These plastids also are very much like Guilliermond's chondriosomes of *Asparagus* referred to above, but several times larger. Smears made from the red-ripe mesocarp, also from the juice, were stained in acid fuchsin, and in these preparations much-better stained and more normally shaped chromoplasts were obtained from the juice smears than the mesocarp. There were some peculiarly shaped bodies in the red-ripe juice due, no doubt, to disintegration processes (pl. 12, figs. 6–9).

In green fruits of *Aglaonema* studied by means of free-hand sections mounted in water, very distinct and typical chloroplasts were observed. In the yellow fruit the plastids seemed to have disintegrated, with the formation of carotin-colored crystals and granules. In the red-ripe stage carmine-red crystals were present, these being smaller but very much the same in shape and appearance as those present in red-ripe tomato. No attempts were made to stain any of this material (pl. 11, figs. 4–5).

Yellow-orange and red stages of *Solanum Dulcamara* (pl. 11, figs. 6–7) and *Solanum Pseudo-capsicum* (pl. 13 fig. 9) and green and ripe stages of *Sorbus sitchensis* (pl. 13, figs. 1–2) were studied by free-hand sections and smears mounted in water. Nothing unusual was noted about the plastids of *Solanum Dul-*

camara or of *Sorbus*, but those of red-ripe Jerusalem cherry were very much elongated with long-drawn-out points. In ripe *S. carolinense* fruit no plastids were ever observed; the pigment, although a carotinoid, was present in oily globules. Fair results were obtained by staining smears of *Solanum Dulcamara* and red-ripe fruits of *Sorbus* in acid fuchsin. Smear mounts made from the juice of red-ripe Jerusalem cherry, stained in acid fuchsin, showed very well-stained chromoplasts, exactly like those of the fresh material. In the red-ripe fruit of *Rhus canadensis* nothing like a plastid was ever found, just a mass of oily globules as in *Solanum carolinense*.

In red-ripe fruits of *Arisaema*, *Celastrus*, *Viburnum*, *Crataegus* (pl. 13, figs. 3–8), *Evonymus americana* (pl. 11, fig. 9), *E. europaea* (pl. 14, fig. 2), *Lonicera* (pl. 14, figs. 4–5), and *Dracaena* (pl. 11, fig. 8) definite plastids were found in smears mounted in water. Especially good results were obtained by staining juice smears of *Arisaema* and *Celastrus* in acid fuchsin. The stained chromoplasts of *Celastrus* were of exactly the same shape and size as the unstained (pl. 18, fig. 3). *Evonymus europaea* was very interesting because the plastids were so very small in the red arils and very difficult to find, no doubt due to the fact that they disintegrate very early and the pigment is present in oily globules, much the same as in *Rhus* and *Solanum carolinense* (pl. 14, fig. 2).

The work on watermelon was rather curtailed owing to lack of material, only red-ripe fruit being available. Smears were made of the mesocarp near the epicarp, where it remains green even in the ripe fruit. In slides made from this region of the mesocarp oval plastids were observed, some of which were green and some pink. In smears made from the red-ripe pulp many carmine-red needle-like crystals with uneven ends were observed, and these were very similar to those in tomato and *Aglaonema* (pl. 14, figs. 6–7).

To determine whether the chromoplasts of a number of fruits are true plastids these decolorization experiments were undertaken. At first thought it seemed an easy matter to remove the color from a chromoplast. Carbon bisulphide had long been known as a ready solvent for carotinoids, especially lycopin (lycopersicin)

and carotin. As these two carotinoids were present in larger proportion than xanthophyll in the fruits studied, carbon bisulphide was the first solvent tried. The first thing to be done was to get rid of all possible water from the tissue, as water and carbon bisulphide are miscible only in small proportions. Small pieces of sections of red-ripe tomato, *Lycium* mesocarp, and *Evonymus europaea* arils were placed in 25, 50, 75, and 100 per cent acetone, 30 minutes for each grade. The color came out and appeared in drops over the surface of cells. The acetone was allowed to evaporate, after which, where these sections were placed in CS_2, much color was drawn out over the tissue but nothing could be determined in regard to the presence of plastids. Several smears of red-ripe *Lycium* juice containing plastids were placed in each of the following reagents, acetone, carbon bisulphide, chloroform, benzole, and petrol ether, and the effect of each reagent observed. The slides standing in petrol ether and those in carbon bisulphide were the only ones that gave up any color to the liquid. On none of the slides could there be any changes noticed in the chromoplasts. The pigment went out of the tissue of red-ripe *Lycium* when placed in warm chloroform for 12 hours, but the tissue was too badly broken up to be of any use in a study of plastids. Sections of red-ripe *Lycium* were dehydrated by means of the usual grades of alcohol. The color almost disappeared in absolute alcohol, but the plastid structure was not clear.

After all these unsatisfactory results a method was tried which proved very successful. For the extraction of all the chlorophyll and carotinoid pigments in green leaves Tsweet ('06) recommended petroleum ether and absolute alcohol (1 per cent absolute alcohol in petroleum ether for dry leaves and 10 per cent for fresh leaves). This method was applied to fruit tissue in these experiments. Small pieces of the tissue were placed in vials containing petroleum ether and 1 per cent absolute alcohol and allowed to stand for 48 hours, after which they were mounted in glycerine and examined with the microscope. Red-pepper tissue gave very good results with this treatment. On these slides colorless plastids very much like those of the chloroplasts showed up in the tissue. Fruits with very small chromoplasts gave fair results but not so satisfactory as the pepper.

From these studies the writer feels sure that at least in most ripe fruits studied the amorphous pigment in a lipoid substratum is contained in a stroma or kind of plastid. At least there is some sort of an accumulation of the cytoplasm at these points. In some fruits great difficulty was encountered in staining the chromoplasts. The best success was obtained by staining smears of juice. Mention should be made of the fact that after killing in chromo-acetic acid these chromoplasts in most of the fruits appeared as colorless bodies of the original form and shape. Very good slides were made showing stained chromoplasts of red pepper, *Lycium*, *Solanum Pseudo-capsicum*, *Arisaema*, *Celastrus*, while rose and *Asparagus* gave only fair results. The decolorization experiments seemed to show without a doubt that the so-called chromoplast is a definite body or stroma and very much like the chloroplast. These so-called chromoplasts increase by direct division, which is another proof of their plastid-like nature. In all of these fruits there was a variation in plastid shape from globose to oval in the chloroplast, while the chromoplasts were elongated, irregular forms. *Asparagus* no doubt showed the most remarkable plastids, for, as has been previously mentioned, their similarity to mitochondria was great.

Lycopersicin crystals are present in the natural red-ripe fruit of tomato, watermelon, and *Aglaonema*. Proof of the fact that the pigment here is really in a crystalline state is as follows: (1) These crystals disappeared when any attempt was made to stain them, (2) no re-crystallization could be obtained by means of the alcoholic-potash method of Molisch. These 3 fruits contain a large percentage of lycopersicin, so that a generalization might be assumed to the effect that lycopersicin, at least, is usually found in a natural, crystalline form. *Solanum Dulcamara* might seem to destroy the value of this generalization because the red-ripe fruit in its natural condition shows no crystals, but exhibits plastids of very much the same shape as the chloroplasts. However, it is quite possible that the pigment in *S. Dulcamara* is not lycopersicin. In *Rhus* there is another interesting condition, which is that the pigment of the red-ripe fruit appears in oil globules, and at no time was I able to see plastids or crystals. In the 6 kinds of natural red-ripe fruit in which lycopersicin was

found it appeared in 3 different conditions, namely: amorphous in a lipoid substratum contained in a stroma; crystalline, free in the cytoplasm; and in oily globules.

It is interesting to note that within the genus *Solanum* the fruit carotinoids appear as crystals in tomato, in plastids in *Solanum Dulcamara*, and as oil globules in *Solanum carolinense.* Again, in *Evonymus americana* there are very definite chromoplasts, in *Evonymus europaea* the pigment is in oil globules. Within the genus *Asparagus* we have carotinoid pigments in *A. officinalis*, while in *A. Sprengeri* the fruit pigment is entirely anthocyanin. The same pigment conditions occur in the genus *Rhus*, for the pigment of *R. canadensis* is a carotinoid, while in *R. glabra* the pigment is anthocyanin.

A Colorimetric Method for the Determination of the Relative Amounts of Pigment in Four Varieties of Tomatoes

Materials and Methods

The purpose of this phase of the investigation was to work out a method by which a colorimeter of suitable type might be used as a means for making quantitative determinations of the pigments contained in tomatoes. Since the principal pigment in tomato is lycopersicin, and CS_2 is a ready solvent for this carotinoid, this solvent was used in making the extractions for examination with the colorimeter. It was necessary to devise methods for drying the tomato pulp, since no previous work had been done along this line.

Four varieties of tomatoes were used, Ponderosa, Excelsior, Globe, and Dwarf Champion. These were grown to maturity in the experimental plots at the Missouri Botanical Garden. Three methods were tested for drying the pulp, and the one yielding the most deeply colored extract, as determined by the colorimeter, was considered the best. For these preliminary determinations no special varieties were employed; however, 2 classes of fruits were used: (1) red-ripe fruit; (2) red-orange fruit. Tomatoes from each of these classes were selected, then skinned by plunging into boiling water for a few minutes. From

the central areas of these tomatoes slices were cut transversely and weighed out in 20-gm. portions, each being carefully crushed up in a mortar and spread out on filter-paper. From this point 3 distinct procedures were followed: (1) Using a dry-heat method, the pulped fruit on filter-papers, 2 containing red-ripe tomato pulp and 2 red-orange, were dried for 6 hours by means of an electric fan, then brought to total dryness in a gas oven at a temperature varying from 40 to 50° C. (2) With the alcohol method 2 filter-papers of each of the 2 lots, as before, were successively covered with 30, 50, and 70 per cent alcohol, remaining covered with each grade for an interval of 30 minutes, after which the alcohol was filtered off by means of a filter pump. Then 95 per cent alcohol was poured on and after evaporation the pulp was entirely dry. (3) Using the acetone method, the same number of filter-papers were successively covered with 50, 70, and 85 per cent acetone, remaining covered with each grade for 30 minutes. Then 100 per cent acetone was added and, as in the alcohol method, upon evaporation the pulp was entirely dry. From each filter-paper the pulp was carefully removed and extracted in glass-stoppered bottles with 25 cc. of CS_2. After 4 days these extracts were examined with a Duboscq micro-colorimeter. The method followed will have to be described in some detail, as a colorimeter of this type is not ordinarily used in this manner.

One of the lower cups of the colorimeter was filled about one-third full with the extract from the red-ripe acetone-dried material, and the other was filled with an equal amount of the extract from the red-ripe alcohol-dried material, then the colors were matched and a reading taken on each scale. Two "day-light" globes were used as a source of illumination. A match was then made between the alcohol-dried and heat-dried material and a reading on the scale recorded. By this same method the extracts of the 2 kinds of tomato pulp dried in the 3 different ways were matched, and readings recorded in table I. Dilutions of 50 per cent and 5 per cent were made of all the extracts matched with the colorimeter, and readings taken. The smaller the scale reading the greater the concentration of the extract, therefore the more of extractable lycopersicin per unit of tomato pulp and

hence the better drying method. The results are recorded in table I.

TABLE I

COLORIMETRIC READINGS IN MM. MADE WITH A DUBOSCQ INSTRUMENT

	No dilution			50 cc. extract, 50 cc. CS_2			5 cc. extract, 95 cc. CS_2		
	Alcohol	Heat	Acetone	Alcohol	Heat	Acetone	Alcohol	Heat	Acetone
Red-ripe tomato	2.5	2.3	1.8	2.3	2.1	1.9	2.0	1.7	1.5
Red-orange "	3.4	1.2	0.8	2.6	0.9	0.8	1.8	0.9	0.5

From the results of this experiment acetone is the best drying agent for tomato pulp, since after drying by this method the most deeply colored extracts were obtained, as indicated by the small readings on the scale. With this problem of the drying determined, so far as the 3 methods described were concerned, the main part of the investigation was undertaken. It was accordingly required to determine the availability of this colorimetric method in estimating the relative amounts of carotinoids in these 4 varieties of tomatoes. In all of these experiments only red-ripe fruits were used.

Experimental Data and Discussion

Experiment 1.—Red-ripe fruits from the 4 varieties of tomato, Globe, Ponderosa, Excelsior, and Dwarf Champion, were skinned, crushed in a mortar, allowed to evaporate 12 hours in evaporating dishes, then placed on filter-papers in Buchner funnels and 5-cc. amounts of acetone poured on at 30-minute intervals until 25 cc. had been used. These filter-papers were then placed in evaporating dishes where in a short time the pulp became entirely dry and ready for extraction after being ground in a coffee mill. One gram of each kind of dried, ground material was placed in a ground-glass-stoppered bottle and extracted with 10 cc. CS_2 for 4 days. Colorimetric determinations were then made by the method indicated above. The results are recorded in table II.

TABLE II

COLORIMETRIC READINGS IN MM.; ACETONE-DRIED RED-RIPE FRUIT, 1 GM. OF MATERIAL EXTRACTED 4 DAYS WITH 10 CC. CS_2

No dilution				50 cc. extract, 50 cc. CS_2			
Excelsior	Ponderosa	Dwarf Champion	Globe	Excelsior	Ponderosa	Dwarf Champion	Globe
0.50	0.70	0.95	1.07	1.40	1.90	3.00	3.10
0.42	0.60	0.80	0.90	0.90	1.20	1.83	1.90
0.42	0.60	0.80	0.90	0.60	0.80	1.22	1.27

Experiment 2.—The same material and methods were used as in experiment 1 (except no Dwarf Champion material was available). The results are recorded in table III.

TABLE III

COLORIMETRIC READINGS IN MM.; ACETONE-DRIED RED-RIPE FRUIT, .5 GM. OF MATERIAL EXTRACTED 4 DAYS WITH 10 CC. CS_2

No dilution			50 cc. extract, 50 cc. CS_2			30 cc. extract, 70 cc. CS_2		
Excelsior	Globe	Ponderosa	Excelsior	Globe	Ponderosa	Excelsior	Globe	Ponderosa
0.53	0.63	1.32	1.25	1.56	4.32	1.02	1.03	1.42
0.25	0.30	0.63	0.80	1.00	2.13	0.86	0.865	1.20

Experiment 3.—Juice from each of the 4 varieties of tomatoes being tested was pressed out, filtered, and the precipitate dried in a gas oven at 60° C. One-tenth of a gram of each kind of dried material was extracted in ground-glass-stoppered bottles with 10 cc. CS_2 for 4 days. Colorimetric determinations were made and recorded in table IV.

TABLE IV

COLORIMETRIC READINGS IN MM.; JUICE PRESSED OUT, FILTERED, DRIED IN OVEN AT 60° C., .1 GM. OF MATERIAL EXTRACTED WITH 10 CC. CS_2 (EXTRACTED 4 DAYS)

No dilution				50 cc. extract, 50 cc. CS_2			
Excelsior	Ponderosa	Dwarf Champion	Globe	Excelsior	Ponderosa	Dwarf Champion	Globe
1.70	3.50	8.30	13.10	3.50	8.40	29.80	37.80
0.88	1.80	4.30	6.80	0.41	1.00	3.50	4.50
0.84	1.60	4.00	6.20	0.57	1.40	4.90	6.30

Experiment 4.—Juice was pressed out from Excelsior, Globe, and Ponderosa, then centrifuged, and the pigment was dried in a dehydrater. Seven-tenths of a gram of each kind of material was placed in a glass-stoppered bottle and each extracted with 20 cc. of CS_2 for 5 days. Colorimetric determinations were made and recorded in table v.

TABLE V

COLORIMETRIC READINGS IN MM.; JUICE CENTRIFUGED AND DRIED IN DEHYDRATER, .7 GM. OF MATERIAL EXTRACTED WITH 20 CC. CS_2 (EXTRACTED 5 DAYS)

No dilution			50 cc. extract, 50 cc. CS_2			30 cc. extract, 70 cc. CS_2		
Excelsior	Globe	Ponderosa	Excelsior	Globe	Ponderosa	Excelsior	Globe	Ponderosa
0.38	0.73	1.16	0.13	0.83	1.33	1.02	1.16	2.41
0.33	0.63	1.00	0.80	0.66	1.03	0.05	0.06	1.35

From these experiments Excelsior tomatoes seem without a doubt to contain the largest amount of lycopersicin of any of the varieties experimented with. There is too much irregularity of results, as may be seen from the tables, to permit of any very definite statement respecting the relative pigment content of the other varieties. This is perhaps an indication of the fact that these 3 varieties, namely, Ponderosa, Dwarf Champion, and Globe, all contain very nearly the same amounts of pigment; and this colorimetric method is only a rough means of determining relative amounts.

Experiment 5.—In an attempt to make a color standard for use in quantitative determinations the question arose as to the stability, with elapsed time, of the color of dried tomato pulp; accordingly a time-factor test was made. The method followed was to find some dye to match a CS_2 extract of the dry, ground-up tomato pulp. One gram of this material was allowed to extract for 4 days in 10 cc. of CS_2, then 15 cc. of this extract were diluted with 3.5 cc. of CS_2. A very good match was obtained for this extract by using Medalia's ('20) methods for colorimetric determinations of H-ion concentration. Three cc. each of N/10 H_2SO_4 and N/10 KOH were placed in tubes to each of which 9 drops of methyl red were added. These tubes, one in front of the other

with a third one in the line containing CS_2, were matched with another set of 3 tubes. In this second set, the first tube contained the pigment extract, the second pure CS_2, and the third H_2O. These tubes were placed in an ordinary wooden comparator. This comparison was made December 20.

On March 30 an extract of the same material of the same strength was matched by the same method. To get a good match this time 7 drops of methyl red had to be added to the H_2SO_4, and 20 drops to the KOH. The extract now was more of an orange-red tint than a true red.

Again, on May 22, an extract of the same strength was made from the same material, but this time only 6 drops of methyl red were added to the H_2SO_4 and 20 drops to the KOH to give a good match. The ground material from which the samples were taken for testing had been kept in a paper envelope in a drawer away from the light. The conclusion is that dried, ground tomato pulp changes in respect to pigment color very gradually, if kept in the dark, during a period of 5 months. However, the lycopersicin carmine-red shade disappeared much more rapidly than the red-orange.

Determinations of the Presence of Certain Pigments in Various Fruits

INTRODUCTION

Definite scientific knowledge of the kind and quantity of carotinoid pigments found in fruits is rather limited, as may be seen from a survey of the literature. The main reason for this is the great difficulty with which the pigments are obtained in a pure state. There are 2 general methods for quantitative estimations, one the gravimetric, the other the colorimetric. The gravimetric method is unsatisfactory for most workers because, in any case, the amount of pigment is relatively small, hence the necessity for such large amounts of the fruit employed. Again, the large proportions of colorless impurities, which are very difficult to separate from the pigments, and the rapidity with which these pigments oxidize cause trouble. The colorimetric method is better adapted for general use, because smaller amounts of

material can be used, but it doesn't seem entirely satisfactory on account of the difficulty with which the standards of really pure carotin and xanthophyll can be prepared and kept in such a state. Substitutes, such as 25 per cent alizarin in chloroform, or a 0.2 per cent aqueous solution of $K_2Cr_2O_7$, are used to good advantage, because of their stability. Willstätter and Stoll ('13), using $K_2Cr_2O_7$ solutions, established a certain set of relations between the standard 0.2 per cent $K_2Cr_2O_7$ and amounts of carotinoids by means of which quantitative determinations of carotin and xanthophyll might be made on any fruit.

In consideration of these rather unsatisfactory results, no actual quantitative determinations were carried out. However, attempts were made to use the colorimeter determinations in connection with a color code, to estimate the relative quantities of pigments in certain fruits. Spectroscopic determinations were made of a number of fruit extracts, and artificial crystallization of these pigments within the tissues was accomplished.

Throughout this investigation the term lycopersicin suggested by Duggar ('13) has been used in place of the older term lycopin.

SURVEY OF LITERATURE

Citrullus vulgaris.—The first work done on the identification of the watermelon pigment was that of the De Negris ('79) who isolated the pigment from the flesh of the fruit and called it rubidin. Courchet ('88) determined that the natural crystals were the same in form and color as those of tomato. Upon agitation with ether the pulp gave almost instantly a beautiful yellow-orange solution, which deepened rapidly in color in proportion to its concentration. The crystals which formed voluminously upon evaporation were needle-like in form or, more frequently, long, slender, carmine-red sheets, which were often contained in sheaths. Montéverdé and Lubimenko ('13) further confirmed the presence of lycopersicin in watermelon. Lubimenko ('14) gave spectroscopic determinations for petroleum ether and CS_2 extractions of the pulp. Nevertheless, the work on this pigment has been very limited, and about the only definite information is the fact that lycopersicin is present in large amounts.

Capsicum annuum.—Pabst ('92) tried to identify the pigment

in pepper with carotin, but was unsuccessful. Kohl ('02), by means of spectroscopic examinations, was able to find no difference between pepper and carrot pigments. Tschirch ('04) found the following absorption bands for pepper: (1) 517.0–501.0 μμ; (2) 486.0–467.0 μμ; (3) 458.0–439.0 μμ, no end absorption. Duggar ('13) obtained the characteristic, bright red lycopersicin color in a CS_2 extract, which gave the distinctive lycopersicin spectrum, 2 bands in the green and 1 in the blue, though no figures were given for the limits of the bands. The name lycopersicin was suggested by him to take the place of lycopin, because lycopin has long been employed to designate a resinoid compound derived from the bugle-weed. Lubimenko ('14) called the pigments of pepper purified by various washings with 95 per cent alcohol a lycopinoid, because its absorption bands were intermediate between pure lycopersicin, which relation the following data show. *Daucus Carota,* which is considered to contain practically no pigment but carotin, gave a spectrum with 3 bands: (1) 533.0–508.0 μμ, (2) 489.0–472.0 μμ, (3) 455.0–445.0 μμ. Pepper showed 3 bands: (1) 560.0–540.0 μμ, (2) 530.0–500.0 μμ, and (3) 495.0–480.0 μμ. *Areca Alicae,* which he considered to give a very characteristic lycopersicin spectrum, gave the following bands: (1) 565.0–540.0 μμ, (2) 520.0–500.0 μμ, (3) 480.0–470.0 μμ. Van Wisselingh ('15), by means of the alcoholic-potash method of Molisch ('13), obtained the pigment in a crystalline form in the tissue of the fruit. These crystals were mostly in the form of aggregates, but others varying in form were present, and they ranged in color from red (Klincksieck et Valette ('08), Code des Couleurs, pp. 16, 21, also 76, 81, and 106, 127) to orange-red and orange. No definite qualitative or quantitative determinations for the pigments contained in pepper have been made.

Solanum Lycopersicum.—The red tomato pigment has been studied by a great many workers, and from definite chemical determinations we know now that it is identical neither with carotin nor xanthophyll. Millardet ('76), the first worker on tomato pigments, soon recognized that it was not identical with either the red or yellow pigments of other fruits. A. and G. de Negri ('79) considered the pigment identical with "rubidin" which they had isolated from watermelon. Ehring ('96), Ar-

naud ('85), and Passerini ('90) all believed the tomato pigment to be carotin, as did also Tammes ('00) and Kohl ('02). Schunck ('03) suggested the name lycopin for the pigment which he was able to extract from the tomato. By difference in spectroscopic analysis and solubility, he decided this pigment was different from his chrysophyll. Montanari ('04) submitted the pure crystalline lycopersicin to chemical analysis and obtained the first evidence of the true relation between lycopersicin and carotin. He obtained an average composition of C = 84.14 per cent and H = 10.88 per cent. He considered this to correspond sufficiently closely to Arnaud's formula $C_{26}H_{38}$ for carotin, which had not been disproved at that time. Molecular weight determinations in benzene, using the cryoscopic method, gave a value of 698, from which he decided it must be a dicarotin with the formula $C_{52}H_{76}$.

Willstätter and Escher ('10) showed that lycopersicin was identical in general composition and molecular weight with carotin, —differing only in degree of solubility in certain solvents, in the position of the absorption bands, in the form and color of the crystals, and in the melting point. They determined lycopersicin to be a true isomer of carotin. Out of 74 kgms. of tomato conserve (canned tomatoes) they obtained 11 gms. of crystalline lycopersicin. Crystals of carotin were also obtained in small amounts as a by-product. The analyses and molecular weight determinations agreed very closely with the theoretical determinations made by Willstätter and Mieg ('07) for carrot. Montéverdé and Lubimenko ('13) have confirmed these figures. From the above work the principal pigment in tomato has been shown to be lycopersicin, although carotin is present in small amounts. Quantitative determinations for lycopersicin have been made.

Rosa rugosa.—Some variation occurs in the pigmentation of the different species of rose as indicated by the literature. Tammes ('00), the first worker, found the pigment constantly gave a blue color with H_2SO_4, HCI, HNO_3, phenol, and bromine water, thus showing the presence of carotinoids. Kohl ('02) noted the occurrence of carotin in *Rosa* sp. Tschirch ('04), employing the method of capillary analysis with *Rosa canina*, obtained a dark orange zone, and his spectrum analysis gave the following bands:

(1) 492.0–475.0 μμ, (2) 462.0–445.0 μμ, (3) 439.0–418.0 μμ. Montéverdé and Lubimenko ('13) isolated lycopersicin crystals from the dried fruit pulp, but they regarded this as a minor constituent of the pigments. Lubimenko ('14) reported the presence of lycopersicin in the chromoleucites in the form of small needle crystals, and included the rose in his list of fruits containing lycopersicin. Van Wisselingh ('15) by means of the Molisch ('13) alcoholic-potash method was able to obtain crystals of carotinoids from *Rosa rugosa*.

Evonymus.—Courchet ('88) found the arils of *Evonymus* to contain fusiform, orange-red chromoleucites in which the pigment was present in the form of needle-like crystals which he called crystallites. The usual blue color reactions for carotinoids with H_2SO_4 and HNO_3 were obtained. Tschirch ('04), in his capillary colorimetric analysis of the alcoholic extract of *E. europaea*, obtained several yellow to red-orange zones. Spectroscopic analysis gave the following bands: (1) 495.0–472.0 μμ, (2) 467.0–439.0 μμ, (3) 430.0–415.0 μμ, with no end absorption. Tammes ('00) examined the arils of *E. latifolius* and found that the plastids gave the characteristic blue color with H_2SO_4, HNO_3, HCl, and bromine water. Lubimenko ('14) classed *E. japonica* as a fruit containing lycopersicin.

Solanum Dulcamara.—Thudichum ('69) classed the pigment of this fruit as a lutein. Hartsen ('73) found a red substance in granular form, crystallizable in tablets, which was the same substance that he found in *Tamus communis* and *Asparagus officinalis*. Tammes ('00) obtained crystals by the Molisch ('13) alcoholic-potash method. Lubimenko ('14) found the chief pigment to be lycopersicin. Van Wisselingh ('15) also obtained crystals by means of the Molisch alcoholic-potash method.

Sorbus.—The first worker on these fruits was Tammes ('00) who reported the presence of carotinoids, as determined by the characteristic reaction with H_2SO_4, HCL, HNO_3, phenol, and bromine water. By means of the Molisch alcoholic-potash method he was able to obtain yellow-red, pointed crystals, single, or in small bundles. Kohl ('02) reported the presence of carotin in *Sorbus Aucuparia* and *S. Aria*. Van Wisselingh ('15), by various methods, found 3 types of crystals in the pericarp, but he did not undertake to classify them.

Asparagus.—Thudichum ('69) classified the pigments found in this fruit with the luteins. Hartsen ('73) found some red substances in the form of granules that were crystallizable in the form of tablets. These pigments were insoluble in H_2O, slightly soluble in alcohol and ether, but especially so in benzene.

Aglaonema.—Tammes ('00) determined the presence of carotinoids in *A. commutatum*, by means of the characteristic color reactions with H_2SO_4, HCl, HNO_4, phenol, and bromine water. Van Wisselingh ('15) obtained by using the Molisch alcoholic-potash method, characteristic carotinoid crystals. *Crataegus* pigments have been very little experimented with, though Thudichum ('69) classed them as luteins.

Other fruits.—On *Solanum Pseudo-capsicum* very little work has been reported. Kraus ('72) observed red and orange-yellow pigment forms in fruit flesh of Jerusalem cherry, and also made spectroscopic determinations of the alcoholic extract. *Lycium* was found to contain carotinoids by Courchet ('88). In *Lonicera*, Schimper ('83) stated that he found red and orange-yellow crystals in the plastids. Courchet ('88) obtained what he called crystallites in the fruit of *Lonicera Caprifolium*. Molisch ('96) and Kohl ('02) obtained crystals by the alcoholic-potash method of the former worker. *Viburnum Opulus* was worked on by Van Wisselingh ('15), who obtained carotinoid crystals by using the Molisch alkaline method but no classification was made of them. Fritsch ('84), who alone has worked with *Celastrus scandens*, described the shape of the chromatophores and observed that they were colored blue and then dissolved with concentrated H_2SO_4, also that iodine colored them blue-green. In *Cucumis Melo*, Courchet ('88) examined the character of the pigments in the plastids, then extracted the pigment and obtained, upon recrystallization, rhombohedral crystals and a few trapezoidal forms orange-red in color. No work has been reported upon the pigments of *Arisaema*, *Dracaena* or *Rhus*. In *Momordica charantia* fruit Duggar ('13) obtained spectroscopic and physiological proof that the principal pigment of the carpels is carotin, but that the aril is characterized by lycopersicin. Courchet ('88), from a recrystallized ether extract of the aril of *Momordica balsamina*, obtained carmine-colored needles, which he found to be identical

in form and color with those obtained from tomato and watermelon. The Toblers ('10a) and Duggar ('13) have confirmed Courchet's observation that the red pigment in the aril of *Momordica balsamina* is lycopersicin.

From this review of the literature it is evident that with the exception of a few fruits such as tomato and pepper very little is definitely known concerning just what carotinoids and in what proportions they are present in fruits.

Daucus Carota.—The first yellow plant pigment to be isolated in crystalline form was carotin from carrots. This pigment was first described by Wachenroder (1826) and called carotin by this worker. This investigation serves as the starting point for our knowledge of the properties as well as the nomenclature of the carotinoids. Vauquelin and Bourchadat (1830) were the next workers, but not until the investigations of Zeise ('47) was carotin isolated from carrots in amounts sufficient for analysis. He discovered its ready solubility in CS_2 and made the first analysis of carotin, giving it the formula C_5H_8, with a melting point of 68° C. This formula was not accepted, however, due to the authority of the next experimenter, Husemann ('61), who worked extensively with carrots. His methods were to press the juice from finely grated carrots, and then add weak H_2SO_4, thus throwing down a coagulum, which was partly dried and extracted with 80 per cent CH_3OH, then this residue dried and extracted with CS_2. The carotin crystals were then precipitated by the addition of absolute alcohol, these being purified by washing with hot 80 per cent ethyl alcohol and finally with absolute alcohol. Husemann was the first to show the unsaturated nature of the carotin molecule, although he regarded the chlorine and iodine derivatives which he was able to make as substitution products. From these analyses he proposed the formula $C_{18}H_{24}O$, and his figures were accepted over those of Zeise ('47).

Arnaud ('85), the next investigator, pressed the juice from grated carrots and precipitated the pigment by the addition of lead acetate, then dried this precipitate *in vacuo* and extracted with CS_2. The residue was washed with cold petroleum ether, and the pigment purified by crystallization from CS_2, with absolute alcohol, and it was then allowed to recrystallize spontane-

ously from cold petroleum ether. About 3 gms. of crystals per 100 kgms. of carrots were obtained in this way. His analysis of freshly prepared crystals showed an average composition of 88.67 per cent carbon and 10.69 per cent hydrogen, thus definitely proving the correctness of Zeise's statement that carotin is a hydrocarbon. This worker for the first time prepared the crystalline iodine derivative of carotin. The elementary composition of this product and the composition of pure carotin led Arnaud to give the formula $C_{26}H_{38}$ to carotin and $C_{26}H_{38}I_2$ to the iodine derivative. Kohl ('02) did a great deal of detailed work on the chemical and physical properties of carotin. His own analyses of the crystalline pigment in carrot gave unsatisfactory results, so he accepted Arnaud's formula as correct. His publication contains an extensive and valuable list of plants and animals containing carotin.

Schunck ('03) obtained a very good yield of crystalline pigment by drying the juice of grated carrot and dissolving in ether. It crystallized in a form very much like the chrysophyll of Hartsen ('73) and Schunck ('01), which was no doubt identical with carotin. He made spectroscopic examinations in which the bands corresponded very closely with those of chrysophyll. Tschirch ('04) cut into pieces carrot which had been soaked in water for a day to remove all sugar, then cooked in water, covered with alcohol for a day, and finally dried by gentle heating. These dried pieces were then ground in a powder mill and extracted in a Soxhlet with petroleum ether of boiling point 60° C. After evaporation of the petroleum ether the residue was crystallized out of alcohol. Later he found it unnecessary to cook the carrot slices, and the soaked pieces were treated immediately with petroleum ether in a Soxhlet. This ethereal extract was allowed to evaporate spontaneously. After a few days the walls of the glass container were covered with the characteristic, dark red to orange, metallic carotin crystals. These were washed with ethyl alcohol and dried under reduced pressure. The alcoholic solutions gave a spectrum with three absorption bands: (1) 487.0–470.0 $\mu\mu$, (2) 457.0–439.0 $\mu\mu$, (3) 429.0–417.0 $\mu\mu$. Solutions in chloroform gave two bands: (1) 507.0–486.0 $\mu\mu$, (2) 473.0–454.0 $\mu\mu$. Willstätter and Mieg ('07) definitely settled the composition of

carotin and proved its identity with the pigments in leaf chloroplasts. They prepared the crystalline material in large amounts, making several extractions with CS_2, which were in alcohol and crystallized from petroleum ether. Their data show a mean ratio of C:H of 1:1.406 for which the simplest formula is C_5H_7. Molecular weight determinations in chloroform and CS_2, using the ebulloscopic method, showed an average of 536, which corresponds exactly with the formula $(C_5H_7)_8$ or $C_{40}H_{56}$—which is now accepted as the empirical formula for carotin. Euler and Nordenson ('08) also isolated carotin from carrots in quantities sufficiently large for analysis. Their results confirmed the Willstätter and Mieg ('07) formula. The purified crystals were also found to contain xanthophyll, which was identified by the color of the crystals and their differences in solubility. Escher ('09), in a very comprehensive paper, gave minute directions for making quantitative determinations of carotin in carrot, methods in which he used both large and small quantities. He confirmed the work of Willstätter and Mieg, but was unable to determine the structural formula, because of impurities in the crystalline material, which he was unable to eliminate. Palmer and Eckles ('14) have shown the presence of xanthophyll in the carrot root by the Tsweet ('06) chromatograph method. Van Wisselingh ('15), using the microchemical methods, was unable to show the presence of xanthophyll crystals in the carrot root. From a survey of this work it is evident that carotin and xanthophyll are the carotinoids in carrot, also that the empirical formula for carotin has been definitely established, and that some quantitative determinations have been made.

MATERIALS AND METHODS

The fruits used were *Lonicera*, *Lycium*, *Citrullus vulgaris*, *Cucumis Melo*, *Aglaonema*, *Arisaema*, *Solanum Dulcamara*, *Viburnum*, *Celastrus* (carpels and arils), *Solanum Lycopersicum*, *Rosa*, *Asparagus*, *Evonymus americana*, and *E. europaea*, *Sorbus*, *Rhus*, *Capsicum*, *Solanum Pseudo-capsicum*, and *Crataegus*. These were all fully ripe fruits.

For drying the fruit there was used a vegetable dehydrater constructed by Dr. G. T. Moore after one designed by the U. S.

Department of Agriculture (Pugsley, '17). For the colorimetric determinations, the same colorimeter was used and the same methods followed as in a previous part of the investigation. All extractions were made with CS_2, the material being first ground in a coffee-mill or mortar. Extractions were then made in ground-glass-stoppered bottles. Klincksieck and Valette's ('08) 'Code des Couleurs' was used for color comparisons.

The instrument used for spectroscopic analysis was an A. Krüss, Hamburg, spectroscope. Two 115-volt, 75-watt Mazda lamps were used, one to illuminate the scale and the other as a source of light for the collimator. All readings were taken with a very narrow slit in the collimator tube. This type of instrument has a movable mm. scale reflected into one of the tubes. The 70th mm. division was adjusted to the sodium flame spectrum, and with this adjustment the flame spectrum of lithium fell at 51 mm., that of calcium at 61 mm., and of rubidium at 160.5 mm. The conversion from mm. on the scale to wave lengths, the standard unit for expression of the width of absorption bands was accomplished by means of an interpolation curve. The method for plotting this curve was taken from Landauer ('07). The divisions of the scale were plotted along the abscissae on coordinate paper; wave lengths from 400 to 750 $\mu\mu$ formed the ordinates. The divisions on the scale where the flame spectra appeared for sodium, calcium, rubidium, and lithium, 60, 61, 160.5, and 51 mm., respectively, were converted into wave lengths by using Rowland's Table, Landauer ('07). A smooth curve was then constructed through these points. Measurements were then made and these scale measurements were then converted into wave lengths by means of the interpolation curve mentioned.

The methods used for crystallization of pigments in tissues were 2: (1) The Molisch ('13) alcoholic-KOH method, and (2) a modification of this. In the first method small strips of the fruit tissue were placed in vials containing alcoholic-potash (40 per cent C_2H_5OH by volume and 20 per cent KOH by weight). These were then put in the dark at room temperature, 20° C., and for a short period out of every 24 hours the temperature was raised to 75° C. They were kept for varying lengths of time until crystallization appeared in the tissues, upon microscopic exam-

ination. The second method, a modification, was proposed by Van Wisselingh ('15) to hasten crystallization. The same process was followed as before, but 10 per cent by weight of KOH and 100 per cent glycerine was used and a constant temperature of 140° C. In this work a constant temperature of 95° C. was found satisfactory. In both methods, after crystallization had taken place, the crystals showed up more clearly if the pieces of tissue were thoroughly washed in distilled H_2O and mounted in glycerine.

EXPERIMENTAL DATA AND DISCUSSION

One gram of each kind of dried, ground fruit tissue was placed in separate ground-glass-stoppered bottles, and 5 cc. of CS_2 added to each and allowed to extract in the dark for 4 days. Then spectroscopic and colorimetric determinations were made, also comparisons with the color code. The results of the spectroscopic analysis are given in table VI, those for colorimetric determinations in table VII, and for the comparison with the color code in table VIII.

Table VI shows that the pigment of tomato, watermelon, *Rhus*, *S. Dulcamara*, *Arisaema*, and *Aglaonema* is largely lycopersicin. These readings approximate those made by Willstätter and Escher ('10) for tomato. They show the limits of the 3 characteristic absorption bands of lycopersicin. The typical lycopersicin absorption bands are 2 in the green and 1 in the blue region of the spectrum. The first band is never so distinct as the second, which is a fact pointed out by Lubimenko ('14) and found to be true in this investigation. Pigments of *Rhus* and *Arisaema* have never been shown to contain lycopersicin before, so far as I was able to ascertain. Other carotinoids are also present in these fruits, as demonstrated in the crystallization experiments. When the CS_2 extracts from these fruits were mixed with equal amounts of petroleum ether, in every case only a very little yellow to orange color appeared in the petroleum ether layer, thus showing the portion of carotin and xanthophyll to be rather small.

The pepper pigment requires some discussion. It has attracted the attention of several workers because of contradictory results. Palmer ('22) calls attention to the fact that the absorption bands given by Tschirch ('04) for the pepper pigment, namely, (1)

TABLE VI

SPECTROSCOPIC ANALYSIS OF VARIOUS FRUITS. EQUAL WEIGHTS OF MATERIAL DRIED IN DEHYDRATER, POWDERED IN MORTAR, AND EXTRACTED 4 DAYS WITH EQUAL AMOUNTS OF CS_2. ABSORPTION BAND LIMITS ARE GIVEN IN $\mu\mu$

Material	Band I	Band II	Band III
Aglaonema Treubii	562.0–548.5	524.0–513.2	495.2–483.2
Solanum Lycopersicum	557.0–536.5	520.0–503.0	485.0–477.5
Rhus canadensis	557.0–536.5	520.0–503.0	485.0–477.5
Solanum Dulcamara	557.0–541.0	522.5–505.0	485.0–476.5
Arisaema triphyllum	557.0–541.0	520.0–503.0	485.0–476.5
Citrullus vulgaris	557.0–541.0	522.5–505.0	485.0–476.5
Celastrus scandens (arils)		531.3–509.2	498.0–485.0
Solanum Pseudo-capsicum		528.5–509.2	494.5–480.0
Celastrus scandens (carpels)		513.2–503.0	480.0–470.0
Evonymus americana		528.2–513.2	494.5–483,2
Lonicera sp.		522.5–509.2	494.5–480.0
Rosa rugosa		522.0 over, shaded no good bands.	
Evonymus europaea		531.3–513.2	483.5–490.0
Asparagus officinalis		531.3–511.3	501.3–488.8
Capsicum annuum		522.5–503.0	494.5–483.2
Lycium halimifolium		522.5–503.0	496.5–480.0
Cucumis Melo		531.3–513.2	501.3–490.0
Viburnum Opulus		513.2–503.0	480.0–476.5
Sorbus sitchensis		513.3–517.5	500.0–485.0

TABLE VII

COLORIMETRIC DETERMINATIONS MADE WITH A DUBOSCQ INSTRUMENT. READINGS GIVEN IN MM. NO DILUTIONS

Rhus	.05	.01	Capsicum annuum	2.9	.7	Citrullus vulgaris	10.5	2.8
S. Dulcamara	1.90	.47	E. americana	5.4	1.5	Lonicera	11.88	3.03
C. scandens (arils)	2.15	.54	Asparagus	6.8	1.9	E. europaea	13.4	3.7
S. Lycopersicum	2.30	.55	Lycium	8.2	2.2	S. Pseudo-capsicum	13.9	3.9
Arisaema	2.30	.57	Rosa	9.1	2.3	Viburnum	16.04	4.5
C. scandens (carpels)	2.35	.60	Cucumis Melo	9.9	2.5	Sorbus	42.4	11.9

517.0 $\mu\mu$–501.0 $\mu\mu$, (2) 486.0 $\mu\mu$–467.0 $\mu\mu$, and (3) 458.0 $\mu\mu$–439.0 $\mu\mu$, and those by Willstätter and Escher do not correspond exactly, but that Tschirch's ('04) bands coincide more nearly with the measurements made by Willstätter and Escher ('10) for carotin, which are 525.0 $\mu\mu$–511.5 $\mu\mu$ and 488.5 $\mu\mu$–474.0 $\mu\mu$. In a true lycopersicin spectrum the band furthest towards the red end of the spectrum should lie at least as far over in the green as 550.0 $\mu\mu$. Lubimenko ('14) does not class the pepper pigment with the fruits he considers to contain lycopersicin, because its absorption bands lie intermediate between pure lycopersicin and pure carotin, and also because he was never able to crystallize this pigment. In my work a good pure lycopersicin spectrum

was never obtained. At times a very faint band appeared in the characteristic position, but never with any degree of certainty. The spectrum obtained always indicated the presence of carotin and xanthophyll rather than lycopersicin. This may be due to the presence of a mixture of lycopersicin and carotin, in which the proportion of carotin is considerably greater than that of lycopersicin, under which condition there is much difficulty in getting distinct absorption bands. Even when greatly diluted with CS_2, the CS_2 extracts of these 6 previously listed lycopersicin-containing fruits exhibit a decided pink color. At equal dilutions the other fruit extracts were orange in color. This interesting phenomenon, due perhaps to dichromatism, is striking in a comparison of the pepper and tomato. From these 2 plants CS_2 solutions of equal strengths are about the same color, but upon dilution with CS_2 the tomato remains red, pink in great dilution, while with corresponding strengths the pepper turns orange in slight dilutions and yellow in greater dilution.

The spectrum analysis of the other fruit extracts require no particular comment. They showed 2 bands, one in the green and one in the blue region. This is a characteristic carotin spectrum.

TABLE VIII

COMPARISON WITH KLINCKSIECK ET VALETTE "CODE DES COULEURS." SAME EXTRACT AS USED IN TABLE VI. FIGURES TAKEN FROM TABLE IN KLINCKSIECK & VALETTE'S "CODE"

Material	Code Readings		
	1	2	3
Solanum Lycopersicum	31	56	56
Rhus canadensis	66	66	66
Solanum Dulcamara	36	51	56
Arisaema triphyllum	51	61	56
Citrullus vulgaris	46	46	46
Solanum Pseudo-capsicum	126	131	126
Celastrus scandens (arils)	56	56	56
Celastrus scandens (carpels)	101	101	101
Evonymus americana	101	106	106
Lonicera sp.	91	96	96
Rosa rugosa	81	81	81
Evonymus europaea	136	131	136
Asparagus officinalis	111	111	111
Capsicum annuum	76	76	76
Lycium halimifolium	106	126	126
Cucumis Melo	91	096	91
Viburnum Opulus	96	0121	0121
Sorbus sitchensis	096	096	096

Table VIII is of little value without the Klincksieck and Valette 'Code des Couleurs.' The smaller numbers represent the true pinks and reds, the lycopersicin shades. Beginning with 76 the red-orange tints come in, which are characteristic of carotin and xanthophyll colors. Again, evidence is obtained from this table that the above-mentioned 6 fruits contain large proportions of lycopersicin. An interesting point is the reading 76 for pepper, which places it nearer the true lycopersicin color than any of the other fruits which are known definitely to contain only carotin and xanthophyll. There is an exception to this in the extract from the arils of *Celastrus* with a reading 56, which I cannot explain.

In table VII, the determinations made with the colorimetre show the relative order of intensity of the pigments contained in the various fruits. According to their strength they have been arranged in descending order in table VII, *Rhus* containing the most concentrated pigment, and *Sorbus* the most dilute.

Crystallization within the fruit tissues was attempted in order to gain more knowledge of the kinds of pigments found within certain fruits. Identification of pigments by means of crystals is not very satisfactory, because of differences of opinion among the various investigators as to the color, shape, and form in which these pigments crystallize. Xanthophyll often crystallizes in quadratic, often trapezoidal tables, frequently showing indentation, or it may crystallize in lance or wedge-shaped prisms. Sometimes the crystals are rhombic, almost hexahedral, with a color variation from greenish yellow to rose. They are not infrequently similar to carotin, but usually contain less color, and are often more pleochromatic.

Carotin crystals are rhomboidal in outline, tabloid or leaf-like in form, and the color is frequently orange to orange-red, but sometimes vermillion, with a steel-blue luster.

Lycopersicin yields brownish rose to carmine-red crystals, usually in the form of needles or minute elongated prisms, and often fissured at the ends. Sometimes crystal aggregates are formed, consisting of elongated prisms, at the center of which the color is a bluish red. Often lycopersicin appears in long, fine, hair crystals.

Certain microchemical tests have been definitely established for these 3 kinds of crystals. Those given here have been taken from Molisch ('13), Willstätter and Escher ('10), Wilstätter and Mieg ('07), Van Wisselingh ('15), and Palmer ('22). All 3 kinds of crystals turn blue when treated with H_2SO_4, HNO_3, or HCl. Lycopersicin crystals give more of an indigo-blue than carotin or xanthophyll. IKI usually turns carotinoid crystals green, although Van Wisselingh found an exception to this in some of the crystals of the *S. Dulcamara* pigment. All 3 give a blue color with chlorozinciodide solution, and the same reaction with bromine water. Xanthophyll crystals turn blue immediately, and are not dissolved by 65–75 per cent H_2SO_4, while carotin crystals turn blue only after the treatment with the acid has continued for some time, or when the acid is stronger. Lycopersicin is dissolved in concentrated H_2SO_4. Carotin and lycopersicin are insoluble in phenol-glycerine (3 parts by weight of phenol and 1 part by weight of glycerine), but xanthophyll is readily soluble.

Xanthophyll crystals are entirely insoluble in low boiling petroleum ether. The solubility in cold methyl alcohol is low, greater in ethyl alcohol, a little greater in CS_2, and still greater in ether. The solubility in acetone and chloroform is quite rapid. Carotin crystals are almost insoluble in cold ethyl alcohol and even less soluble in methyl alcohol, and they dissolve with difficulty in hot alcohols. Their solubility in low boiling petroleum ether is poor, but somewhat greater in the higher boiling ones. Acetone dissolves them with difficulty, even when hot. Benzole dissolves them more easily, chloroform and CS_2 with great ease. Lycopersicin crystals are less soluble than carotin in all the carotinoid solvents. Ethyl and especially methyl alcohol are exceptionally poor solvents. Petroleum ether of low boiling point dissolves only a small amount, while ether is a better solvent, but CS_2 is much better. In CS_2 a 2 per cent solution may be obtained. These crystals are insoluble in acetone and glacial acetic acid.

According to the methods described above attempts were made to crystallize the pigments in the tissue of each kind of fruit used in this section of the work. In some fruits no crystals could be obtained.

In tissue of Jerusalem cherry placed in alcoholic potash solution, long, bright red needle-like crystals and a few aggregates were observed after 16 days (pl. 18, fig. 2). Oftentimes small needle crystals were seen within the cells. No success was obtained with the Jerusalem cherry material placed in glycerine potash. In tissue of *Arisaema* there was no crystallization after 21 days in either alcoholic or glycerine potash. Tissue of *Celastrus* after 16 days showed rather short orange and yellow needle crystals (pl. 15, fig. 5). Tissue of *Sorbus* placed in alcoholic potash solution yielded many very fine pale yellow-orange crystals (pl. 15, fig. 7). Tissue of *Lonicera* under the same conditions showed orange to yellow crystals (pl. 15, fig. 1), but broader than those of *Sorbus*, and more like the xanthophyll crystals pictured by Willstätter and Stoll ('13).

The crystals formed in the pepper tissue were of special interest, due to the uncertainty of the presence of lycopersicin. Strips of tissue were placed in both potash solutions, but the best results were obtained after 16 days in the alcoholic potash. The crystals were of 2 types, the typical rhomboidal tabloid or leaf-like forms, which were orange to orange-red, with a metallic luster so characteristic of carotin, as described by Willstätter and Escher ('10); and rose-red rosette-like crystals, which is one of the forms ascribed to lycopersicin and one of the types found in tomato (pl. 15, fig. 6).

A great variety of crystals was produced in the *Asparagus* tissue by the glycerine-potash treatment after 10 days. Some indications of carotin, xanthophyll, and lycopersicin were obtained (pl. 15, fig. 11). In *Evonymus europaea* crystals formed more rapidly than in any other tissue, which is no doubt due to the fact that the pigment is already present in an oily substrate distributed through the entire cell. Van Wisselingh ('15) gives a very interesting explanation of how these crystals are formed by the application of the Molisch method. He says the pigments are dissolved within the plastids in an oily substance, then through treatment with alcoholic potash the plastid or stroma is destroyed and the pigment rounds up into colored globules; the KOH then saponifies the oily substance and the pigment is set free, crystallizing in the alcohol, in which carotinoids are not very soluble. Heat no doubt

increases the saponification process. When fruit tissues are placed in either of these KOH solutions the first change to be noted is the formation of colored globules. Since the plastids in *E. europaea*, at the point of highest coloration of the aril, are already broken down and the pigment is distributed in oily globules, the addition of the alkali effects at once the saponification of the lipoid material and the precipitation of the pigment in a crystalline form, thus accounting for the rapid crystallization in this tissue. The crystals appeared to originate from the colored globules mentioned (pl. 14, fig. 1, pl. 17, fig. 4). After 5 days in glycerine potash *Crataegus* showed very distinct carotin crystals of a deep vermilion red with the characteristic metallic luster (pl. 15, fig. 3). After 10 days in alcoholic potash there were formed in the fruit of *S. Dulcamara* beautiful carmine crystals of lycopersicin similar to those shown by Willstätter and Mieg ('07) (pl. 15, fig. 8, pl. 17, fig. 2). Good lycopersicin crystals were obtained in the tissue of *Rhus* after treatment of 30 days with alcoholic potash (pl. 15, fig. 4). With *Evonymus americana* an interval of only 7 days in the solution was required in order to produce many fine needle crystals, orange-yellow in color (pl. 17, fig. 3). In *Lycium* the crystals observed in the cells after a treatment of 7 days with alcoholic potash were rather broad needles (pl. 15, fig. 2).

Some of the tests described earlier were applied to certain of these crystals. *Lycium, Celastrus, Sorbus, Aglaonema, Asparagus,* and *Crataegus* all gave a green color with IKI solution. With the exception of *Sorbus,* crystals from the same fruits gave a blue reaction after a treatment of 1 hour with 85 per cent H_2SO_4. In *Sorbus* the crystals changed color almost immediately, thus indicating the presence of xanthophyll rather than lycopersicin or carotin. No results were obtained with bromine water nor acetic acid. Phenol-glycerine dissolved some of the crystals in the *Sorbus* tissue, but this reagent had no effect upon most of the crystals.

From the results of this work it is difficult to draw conclusions as to just which carotinoids are present in all of these fruits. All the workers on fruit pigments have agreed that lycopersicin is the principal carotinoid in tomato, watermelon, *Aglaonema*

(several species) and *Solanum Dulcamara*; while by some workers pepper and rose are added to this list. The results of this work confirm the presence of lycopersicin in tomato, watermelon, *Aglaonema Treubii* and *Solanum Dulcamara*, adding to the list *Arisaema triphyllum* and *Rhus canadensis*. The presence of lycopersicin crystals in pepper is certainly an evidence of the presence of the pigment, the failure to get good characteristic lycopersicin absorption bands no doubt being due to the small proportion of the pigment in pepper tissue. I have found no indication of lycopersicin in rose, although Lubimenko ('14) lists the rose among fruits that do contain it. In some fruits the spectroscopic work and the crystallization are rather contradictory. In Jerusalem cherry the long, pinkish red, needle crystals characteristic of lycopersicin were found, while in *Asparagus* tissue rosette crystals, also characteristic of lycopersicin, were observed. From the spectroscopic determinations there was no indication of lycopersicin in either of these tissues.

Some fruits were found to contain both anthocyanin and carotinoid pigments. These were *Crataegus*, *Rosa*, *Sorbus*, *Lonicera*, and *Viburnum*. In each fruit the anthocyanin pigments were located in the cells of the epicarp. As these pigments are soluble in the sap and not contained in plastids, these cells appeared as if filled with a colored liquid. The mesocarp tissue when examined under the microscope contained many plastids. All of these fruits when boiled in water lost their bright external colors, but the carotin-colored plastids remained without any change.

Since the anthocyanin pigments when in combination with carotinoids in the same fruit were always in superficial cells, the writer accepts the view that perhaps light is a strong factor in effecting this type of distribution. It would seem that light is more necessary for the production of anthocyanin than for carotinoid pigments. No satisfactory experimental work has been carried out during this investigation to substantiate this theory. Observational evidence is both for and against the idea. The most highly colored apples are raised in the regions of most intense light, also the brightest colors of most fruits such as peaches, plums, grapes, pears, strawberries, etc., are in the epicarp

or close to the surface of the fruit, where the light is greatest. Among roots we find certain ones that are highly colored with anthocyanin, such as red beets, radishes, and turnips; in other cases the pigments are carotinoids, as in carrot. According to Wheldale ('16) few definite experimental data have been accumulated and the evidence is very conflicting. Some flowers and fruits grown in the dark develop color while some do not. A general survey of the distribution of anthocyanin shows without a doubt that it occurs most often in the external tissue.

The beet root is a good illustration of the development of an anthocyanin pigment practically in darkness. A few other instances are recorded of pigment formation in the dark. Wiesner ('77) observed that potato sprouts, which formed in the light, showed little, if any, yellow pigment, while those formed in the dark developed from 30 to 150 per cent more pigment. Elfving ('82) and Immendorff ('89) found that carotinoids increased greatly in leaves under conditions which depressed chlorophyll formation, that is, low temperature and very diffuse light. Lubimenko ('14) maintained that light was not necessary for the formation of lycopin. Duggar ('13) proved that light is absolutely unnecessary for the normal pigmentation of red tomatoes.

Evonymus europaea offers an interesting condition, for here the arils colored with a carotinoid become bright red before the colorless carpels have burst open. The carpels are later colored by an anthocyanin. After the carpels break open they assume a rosy red color. An experiment was tried in which some green fruits of *Evonymus europaea* were placed in the dark and some in the light at the same temperature and at the same humidity. No satisfactory results were obtained as the small fruits dried up without any decided appearance of color in the carpels, under either set of conditions.

Gaultheria ovatifolia Gray, *Symphoricarpus orbiculatus* Moench, *Fragaria* sp. (cultivated), *Rubus spectabilis* Pursh, *Sambucus callicarpa* Greene, *Vaccinium parvifolium* Smith were found to contain only anthocyanin pigments.

Two tests were made to determine what kind of pigments are present in these fruits. (1) Each kind of fruit was boiled and in every case a colored liquid was obtained and a decrease or entire

loss of color in the fruit itself. (2) Air-dried and powdered material of each fruit was treated with CS_2 and allowed to stand for 2 weeks. No colored extract was ever obtained with any of the fruits tested.

CARROT PIGMENTS

Experiment 1.—To determine the state in which carotin is found naturally occurring in the carrot root, thin, free-hand sections of mature carrot containing an abundance of crystals were cut and placed in vials containing petroleum ether and absolute alcohol (10 cc. of petroleum ether and 1 cc. of absolute alcohol) maintained in darkness (pl. 15, figs. 9–10). Upon examination with the microscope after 48 hours no evidence of any crystals or granules could be found in the tissue, and no trace of color remained.

For the same purpose microtome sections, 10 μ in thickness, of mature carrot material, killed in chromo-acetic and imbedded in paraffin were stained in Delafield's haemotoxylin as described by Chamberlain ('15). Upon examination under the microscope no crystals or granules were observed in these slides.

Free-hand sections from the same region of the carrot were placed in iodine and 70 per cent alcohol and left in darkness for 24 hours. Upon examination with the microscope after this treatment no color bodies were observable in the tissue. From these experiments the conclusion was drawn that in the mature carrot root the pigment is in a crystalline or granular form free in the cytoplasm and not contained in any plastid or stroma, otherwise some evidence of a stroma would have appeared in the sections treated by the above 3 methods. The size, shape, and general form of most of these color bodies under the microscope indicated the presence of crystals rather than granules.

Experiment 2.—To study the question of where and how the carotinoids in carrot are formed, very young carrot roots were examined both by means of free-hand and paraffin sections. The microtome sections proved to be of little interest as the pigment itself was dissolved by all of the methods used. Free-hand sections were cut from very young carrots from 3 regions: (1) very close to the root tip, (2) half way between the root tip and the

top, and (3) at the top of the root just where the stem joins the root. Sections from these 3 regions were all tested for starch with IKI. Sections from region (1) gave no test for starch, from region (2) very good starch tests. An abundance of leucoplasts could be seen before the IKI was added, and in some sections a peculiar arrangement was noted between the carotin-colored bodies, which were sparingly present and the starch (pl. 16, fig. 9). There was a close connection between these starch grains and masses of pigment, as indicated by the blue coloration and the orange pigment. Leucoplasts containing starch inclusions were also observed (pl. 16, fig. 12). Sections cut from region (3) gave practically no starch test, but an abundance of chloroplasts were present and in addition many tiny carotin crystals in the fibro-vascular bundles. Upon the addition of H_2SO_4 these crystals gradually turned blue, and green with IKI, two decisive tests for carotin (pl. 16, fig. 11).

Experiment 3.—Mature carrots often show a green coloration near the top of the root. Sometimes this extends down into the center of the vascular cylinder. Tests were made for starch and sugar by means of IKI and Fehling's solution respectively. An abundance of starch was present but no sugar, and more starch was found to be present in the top region than in the bottom. Sections cut about .5 mm. in thickness from mature carrots and examined under the low power of the microscope showed very distinctly that the arrangement of the great masses of pigment followed the medullary rays (pl. 16, fig. 10).

Experiment 4.—To show the distribution relation between the chloroplasts and carotin crystals, a mature carrot was divided into 4 regions, each 1 cm. wide. From each region free-hand sections were cut, mounted in water, and examined under the microscope. Beginning at the top these regions were numbered 1, 2, 3, and 4. In each region sections were cut from the vascular cylinder and the cortex. In region (1) the sections from the cortex showed only chloroplasts, while those from the vascular cylinder showed chloroplasts and some carotin crystals. In region (2) the cortex sections showed only chloroplasts, while the vascular cylinder only greenish yellow and orange crystals. In region (3) the cortex sections contained both chloroplasts and carotin crystals, some

of the latter being of good size. In the vascular cylinder sections many carotin crystals and a few chloroplasts were observed. In region (4) the vascular cylinder sections contained many large carotin crystals, while the cortex contained many very large carotin crystals and also an abundance of smaller ones and granules but no chloroplasts. These crystals were of various shapes and forms with some variation as to color. They varied in size from 2.1 to 3 μ by 10.0 to 42.7 μ. Color variations were from pale orange to red (pl. 16, figs. 1–8).

Experiment 5.—This part of the work was undertaken to determine whether mitochondria are present or not in carrot. Both mature and various stages of young carrot roots were killed by Renand's IV B method, imbedded in paraffin, and stained in Haidenhain's iron-haematoxylin (Cowdry, '18). No definitely staining bodies resembling mitochondria could be found. Many chloroplasts stained well in the region where root and stem join (pl. 16, fig. 13).

From these experiments the following conclusions seem warranted: (1) The carrot carotin is typically in a crystalline or granular state, and not contained in a stroma. This is opposed to the conception of Schimper ('83) who considered the carrot carotin to be contained in chromoplasts. (2) Carotin is laid down as a storage product in the medullary rays. (3) The amount of carotin crystals increases from the top of the root towards the bottom, while the chloroplasts decrease. (4) No evidence could be found of mitochondria in young carrot roots.

Ripening Experiments

EXPERIMENTAL DATA AND DISCUSSION

These experiments were undertaken in an attempt to determine the most favorable temperature for rapid fruit ripening, that is, to bring the fruit to the point of red ripeness. Very little work has been done on temperature relations. Duggar ('13) in some experiments with tomatoes showed that light was unnecessary for normal ripening, and that the most favorable temperature range was 18–25° C. In another experiment he found that red peppers ripen normally at higher temperatures.

Experiment 1.—Green fruits of *Lycium halimifolium* Mill. were placed under 4 different conditions, 9 fruits in each lot. These conditions were as follows: (1) wrapped in black paper in a drawer at 17–20° C.; (2) in front of west window at 18–22° C.; (3) in an incubator at 26–28° C.; (4) in an incubator at 32–35° C. The results are given in table IX.

From these data the rapid factor in ripening fruits is shown to be heat and not light, a temperature of from 26–28° C. being the most favorable. These results agree with those found by Duggar ('13), although he was working with pepper.

Colorimetric determinations were made of the red-ripe fruit from each lot. These fruits were dried in a gas-drying oven at 60° C., ground up in a mortar, and extracted with CS_2 (0.3 gm. of dried material in 4 cc. of CS_2 extracted for 4 days). The methods were the same as those already indicated.

TABLE IX

COLOR CHANGES IN GREEN LYCIUM FRUITS UNDER 4 DIFFERENT RIPENING CONDITIONS DURING A PERIOD OF 5 DAYS. NOTES ON 9 FRUITS IN EACH LOT.

Days	Lot 1 17–20° C. Wrapped in black paper put in desk	Lot 2 18–22° C. On table in front of west window	Lot 3 26–28° C. In electric oven	Lot 4 32–35° C. In electric oven
1	5 green 2 yellow 1 almost orange 1 orange	6 green 2 yellowish green 1 orange	1 green 1 yellow 2 nearly orange 5 orange	3 green 3 yellow 3 orange
2	1 green 3 yellow 2 orange 3 red-ripe	2 green 4 yellow 3 orange	1 green 1 yellow 1 orange 6 red-ripe	1 green 2 yellow 2 orange 4 red-ripe
3	1 green 3 yellow 2 orange 3 red-ripe	1 green 1 pale yellow 4 yellow 2 orange 1 red-ripe	1 green 1 orange 7 red-ripe	1 green 2 yellow 6 red-ripe
4	1 greenish yellow 3 yellow 1 orange 4 red-ripe	4 yellow 4 orange 1 red-ripe	1 yellow 1 orange 7 red-ripe	2 green 1 yellow 6 red-ripe
5	1 greenish yellow 3 yellow 1 orange 4 red-ripe	4 yellow 3 orange 2 red-ripe	1 yellow 1 orange 7 red-ripe	2 green 1 yellow 6 red-ripe

TABLE X

COLOR CHANGES IN GREEN PEPPERS UNDER 5 DIFFERENT RIPENING CONDITIONS DURING A PERIOD OF 42 DAYS, 20 FRUITS IN EACH LOT*

	Lot 1 26–28° C. Wrapped	Lot 2 22–24° C. Unwrapped	Lot 3 20–22° C. Unwrapped	Lot 4 16–18° C. Unwrapped	Lot 5 14–16° C. Wrapped
6 days	2 red-ripe 8 almost red-ripe 7 red-orange 3 green, few red-orange spots	4 one-half orange to red-spotted 10 orange to red-spotted 6 green	3 red-ripe 5 almost red-ripe 5 two-thirds red-ripe 2 green, red spots 5 green	1 red-ripe 3 almost red-ripe 1 one-half orange-red 11 one-fourth orange-red 1 three-fourths green 3 green	4 half orange to red-spotted 10 orange to red-spotted 6 green
12 days	4 almost red-ripe 11 three-fourths red-ripe 2 few orange-red spots 1 spoiled	5 red-ripe 3 red-ripe beginning to spoil 9 almost red-ripe 2 three-fourths red-ripe 1 one-fourth red-ripe	4 red-ripe 5 almost red-ripe 1 three-fourths red-ripe 5 one-fourth red-ripe 1 few yellow spots 1 green	4 red-ripe 11 three-fourths red-ripe 1 yellow 1 green-yellow striped 2 green	2 almost red-ripe 9 three-fourths red-ripe 5 green, orange-red spots 3 green 1 spoiling
18 days	2 red-ripe 4 almost red-ripe 9 three-fourths red-ripe 2 few orange-red spots	3 red-ripe 6 almost red-ripe 1 three-fourths red-ripe 5 spoiled	1 red-ripe 3 almost red-ripe 5 three-fourths red-ripe 4 spoiled	2 red-ripe 7 almost red-ripe 3 three-fourths red-ripe 3 spoiling	4 almost red-ripe 8 three-fourths red-ripe 2 one-third red-ripe 3 few red spots 1 yellow 2 spoiled
24 days	4 red-ripe 9 almost red-ripe 2 three-fourths red-ripe	5 red-ripe 2 almost red-ripe	6 almost red-ripe 2 three-fourths red-ripe	8 almost red-ripe 2 three-fourths red-ripe 3 spoiled	8 almost red-ripe 3 three-fourths red-ripe 3 one-half red-ripe 1 yellow 3 spoiling
30 days	2 red-ripe 8 almost red-ripe 1 three-fourths red-ripe	1 red-ripe 1 almost red-ripe	3 red-ripe 3 almost red-ripe 2 three-fourths red-ripe	2 red-ripe 6 almost red-ripe 2 three-fourths red-ripe	4 red-ripe 4 almost red-ripe 3 three-fourths red-ripe 1 yellow 6 spoiled

* As soon as a pepper became red-ripe or spoiled a record was no longer kept of it.

TABLE X (Cont.)

	Lot 1 26–28° C. Wrapped	Lot 2 22–24° C. Unwrapped	Lot 3 20–22° C. Unwrapped	Lot 4 16–18° C. Unwrapped	Lot 5 14–16° C. Wrapped
36 days	7 red-ripe 2 almost red-ripe	1 red-ripe	3 almost red-ripe 2 three-fourths red-ripe	3 red-ripe 4 almost red-ripe 1 three-fourths red-ripe	4 almost red-ripe 3 three-fourths red-ripe 1 yellow
42 days	2 red-ripe		3 red-ripe 2 almost red-ripe	4 almost red-ripe 1 three-fourths red-ripe	5 almost red-ripe 2 three-fourths red-ripe 1 yellow

The results showed that fruits ripened under the condition of lot 3 give a more deeply colored extract than any of the others. From this it was concluded that 26–28° C. is the most favorable temperature for ripening fruits of *Lycium*. The temperature range doesn't agree with that of Duggar ('13) for tomato, but the presence of a large percentage of lycopersicin in tomato and none in *Lycium* may account for this difference.

Experiment 2.—Bell peppers of uniform size and greenness, 20 in each lot, were placed under 5 different conditions as to temperature and light. Lot 1 was placed in an electric incubator (26–28° C.), each fruit being first wrapped in brown paper to prevent too much drying out; lot 2 on a table in front of a south window (22–24° C.) unwrapped; lot 3 on the floor (20–22° C.) unwrapped; lot 4 on the floor (16–18° C.) unwrapped; lot 5 on the floor (14–16° C.) wrapped. Detailed color notes taken at 6-day intervals are given in table x. From these results 22–24° C. is the best temperature for ripening peppers, the higher temperatures being more favorable, however, than the lower. Light is not a controlling factor.

Spectroscopic determinations were made on samples from peppers ripened under conditions of experiment 2. The methods followed in this work have been previously described. The pulp of the red-ripe fruits from each lot, after removal of the seeds, was placed in the dehydrater until perfectly dry, then ground as fine as possible with a coffee mill. Weighed amounts of this material were then extracted with relatively equal portions of CS_2 for 2 days. The extract in all cases was too dense to show absorption

bands. The whole spectrum was blotted out from 652.2 μμ over to 412.5 μμ, so that dilutions had to be made before the absorption bands could be observed. The amount of dilution varied with the different lots of peppers. The absorption bands in all lots lay approximately in the region of the carotin and xanthophyll spectrum. These spectroscopic analyses are given in table XI. The most concentrated extract was believed to indicate the best ripening condition.

TABLE XI

SPECTROSCOPIC ANALYSES OF PEPPER EXTRACTS FROM EXPERIMENT 2. ALL MEASUREMENTS ARE IN μμ.

Lot	1	2	3	4	5
Dilutions	2 cc. extract 10 cc. CS_2	2 cc. extract 11 cc. CS_2	2 cc. extract 8 cc. CS_2	2 cc. extract 5 cc. CS_2	2 cc. extract 3 cc. CS_2
Absorption bands	(1) 522.5–505.0 (2) 494.2–483.0	(1) 523.5–507.3 (2) 497.5–482.0	(1) 521.5–506.5 (2) 496.5–482.0	(1) 523.2–507.5 (2) 497.5–483.0	(1) 522.6–507.5 (2) 497.5–483.0

The same conclusion was drawn from these results as from experiment 2. Lot 2, with a temperature range of 22–24° C., offered the most favorable temperature for fast ripening. Lot 1 ripened at 26–28° C., the next most favorable. Lot 5, ripened at 14–16° C., gave a very weak extract needing only about one-fourth the dilution of lot 2.

Experiment 3.—These extracts from experiment 2 were further tested by comparison with Klincksieck et Valette's 'Code des Couleurs.' The method followed was to dip 3 equal-sized pieces of filter-paper in each of the 5 extracts obtained from experiment 2. These were allowed to dry for 5 seconds and then a comparison made with the charts. Three readings were made for each extract. In most cases these triplicate readings were exactly the same. They are recorded in table XII.

TABLE XII

PEPPER EXTRACT FROM FRUITS RIPENED UNDER CONDITIONS OF EXPERIMENT 2. COLOR FIGURES TAKEN FROM KLINCKSIECK & VALETTE'S "CODE"

Lot	1 26–28° C.	2 22–24° C.	3 20–22° C.	4 16–18° C.	5 14–16° C.
Readings					
1	61	66	66	71	71
2	61	66	66	71	71
3	61	61	66	71	71

Since the smaller the figures the deeper the color this experiment is further proof that higher temperatures (22–24° C.) are necessary for deep pigmentation of fruits during the ripening process.

Experiment 4.—Color changes on the individual pepper were observed with green fruits placed in the dark at a temperature of 22–25° C. The first changes were a few yellow spots, then darkening of these spots to an orange, then to an orange-red. Finally this orange-red color spread gradually over the entire fruit until red-ripeness was reached. These same color changes were observed in 12 individual fruits.

Summary

1. During the ripening process of fruits a change occurred in the general shape of the plastids from oval or subglobose to a very much elongated spindle form. In some of the red-ripe fruits the pigment was crystalline in form.

2. In most of the ripe fruits studied the pigment was found to occur in a stroma or in a definite body. This pigment was in an amorphous state contained in a lipoid substratum.

3. Lycopersicin was present in a crystalline form in the red-ripe fruits of *Solanum Lycopersicum*, *Cucumis Citrullus*, and *Aglaonema Treubii*.

4. A Duboscq micro-colorimeter was used with good results as a means of determining relative amounts of pigments in tomatoes. Of the 4 varieties studied, Ponderosa, Excelsior, Dwarf Champion, and Globe, Excelsior was found by this method to contain the most pigment.

5. Dried tomato pulp kept in the dark for a period of 5 months lost very little color. This was proved by comparisons of the CS_2 extract of the dried material, at certain intervals, with a methyl red solution.

6. A characteristic lycopersicin spectrum was obtained with a CS_2 extract of the pigments in the ripe fruits of the following: *Aglaonema Treubii*, *Solanum Lycopersicum*, *Rhus canadensis*, *Solanum Dulcamara*, *Arisaema triphyllum*, and *Citrullus vulgaris*.

7. A characteristic carotin spectrum was obtained with a CS_2 extract of the following fruits: *Celastrus scandens*, *Solanum Pseudo-capsicum*, *Evonymus americana*, *Lonicera* sp. *Rosa rugosa*,

Evonymus europaea, *Asparagus officinalis*, *Capsicum annuum*, *Lycium halimifolium*, *Cucumis Melo*, *Viburnum Opulus*, and *Sorbus sitchensis*.

8. Only anthocyanin pigments were found in the fruits of *Gaultheria ovatifolia*, *Symphoricarpus orbiculatus*, *Fragaria* sp., *Rubus spectabilis*, *Sambucus callicarpa*, and *Vaccinium parvifolium*. Both anthocyanin and carotinoid pigments were found in the fruits of *Crataegus phaenopyrum*, *Rosa rugosa*, *Sorbus sitchensis*, *Lonicera* sp., and *Viburnum Opulus*.

9. The carrot carotin occurred in both crystalline and granular forms, but free in the cytoplasm. It appeared to be laid down as a storage product in the medullary rays.

10. The optimum temperature for the rapid ripening of *Lycium halimifolium* fruits was 26–28° C. The optimum temperature for the rapid ripening of pepper fruits was 22–24° C.

The writer wishes to express her appreciation of the valuable suggestions and kindly criticisms of Doctor B. M. Duggar, under whose direction the work was carried out. Thanks are also due Doctor J. M. Greenman for the verification of all scientific names, and to Doctor G. T. Moore for the privileges and facilities of the Missouri Botanical Garden.

Graduate Laboratory, Missouri Botanical Garden.

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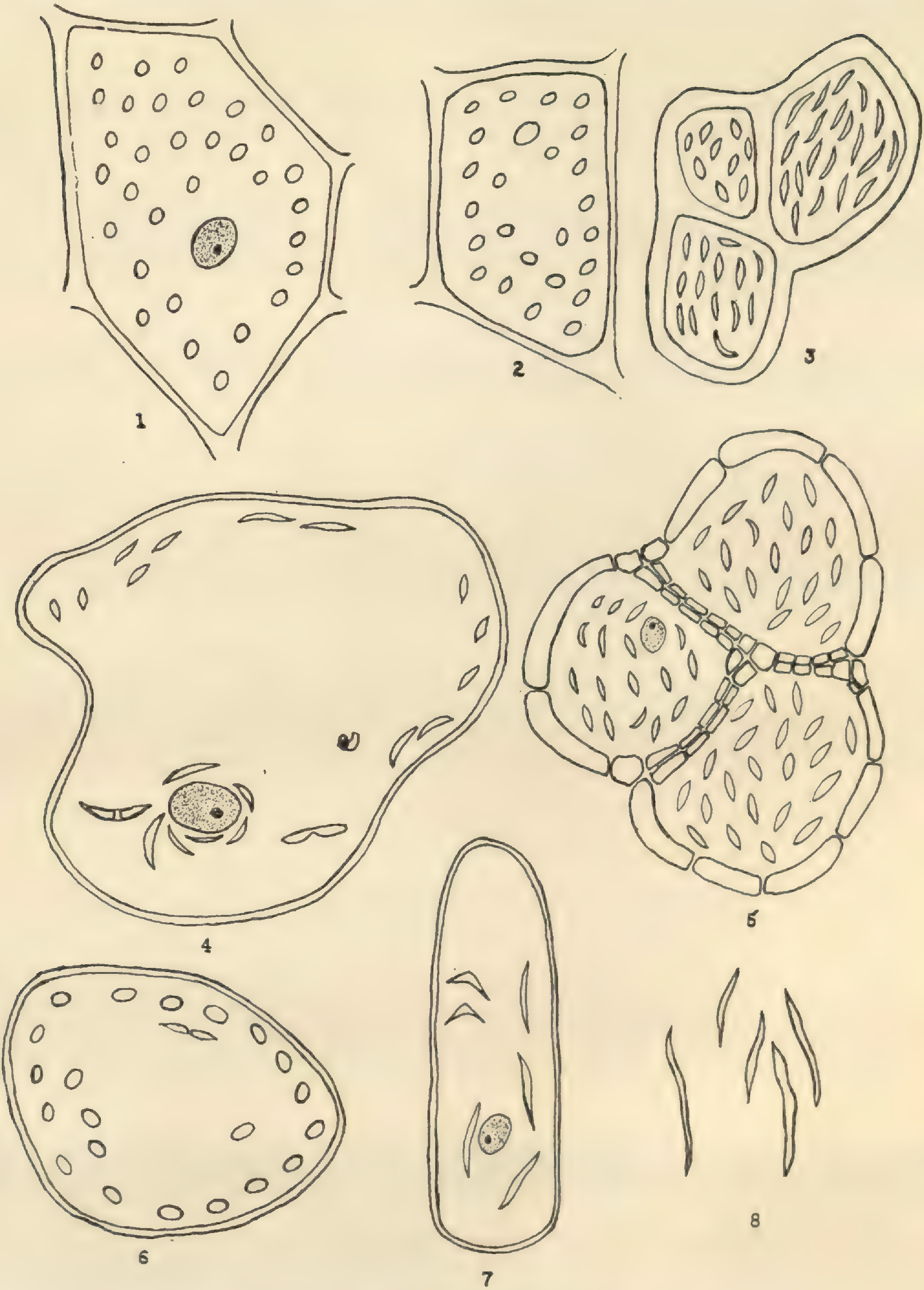
Explanation of Plate

PLATE 10

(Camera-lucida drawings, × 880)

Figs. 1–5. *Capsicum annuum:* figs. 1–3, successive changes in plastid shapes during ripening; fig. 1, from green pulp; fig. 2, from yellow-orange pulp; fig. 3, from epicarp of ripe fruit; fig. 4, from microtome sections of ripe pepper stained with iron-haematoxylin; fig. 5, from free-hand sections, stained in acid fuchsin.

Figs. 6–8. *Rosa rugosa.* Successive changes in plastid shapes during ripening: fig. 6, from green pulp; fig. 7, from yellow-orange pulp; fig. 8, from ripe pulp.



HOWARD—CAROTINOIDS IN FRUITS

Explanation of Plate

PLATE 11

(Camera-lucida drawings, × 880)

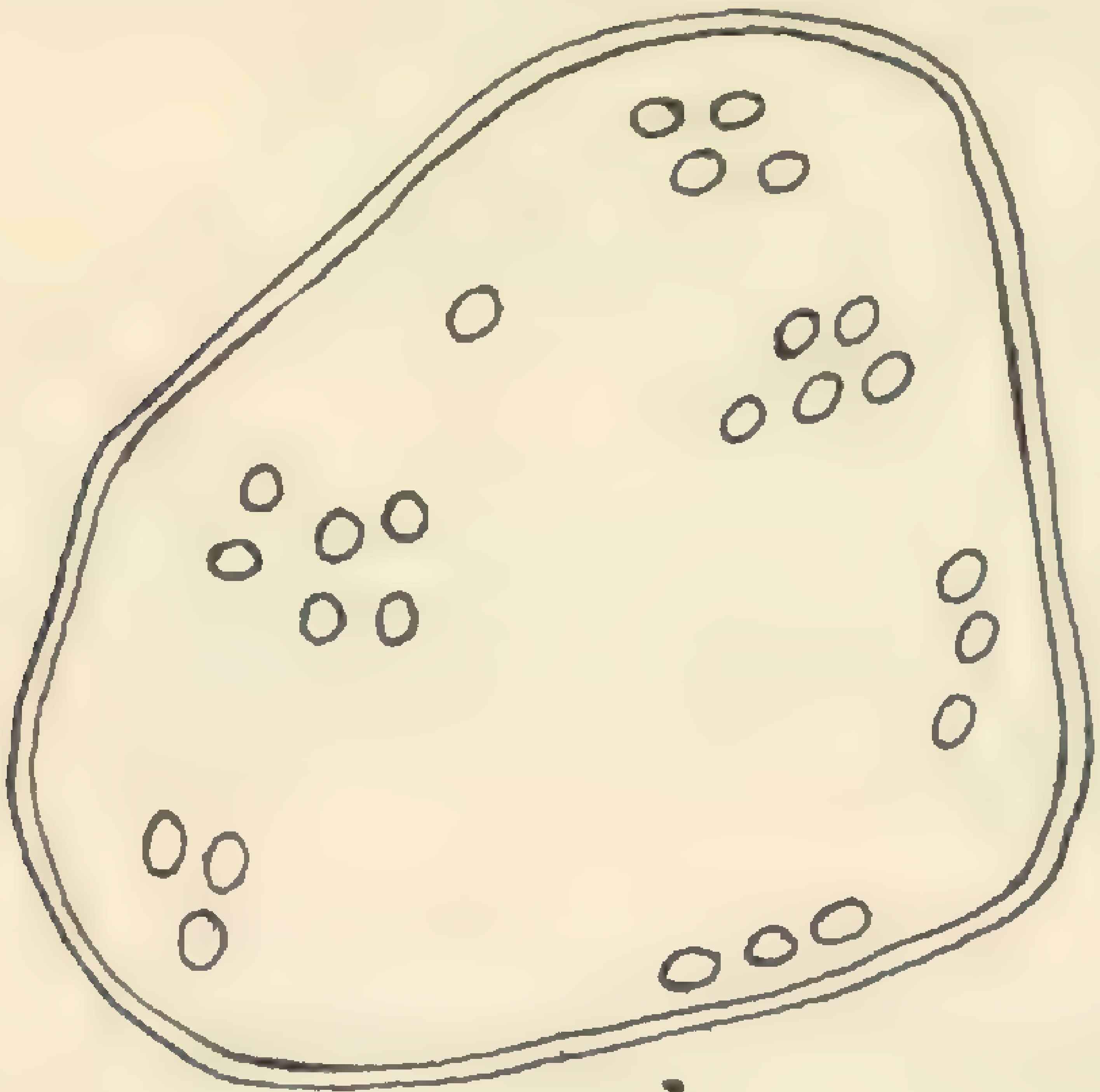
Figs. 1–3. *Solanum Lycopersicum:* figs. 1 and 2, successive changes in plastid shapes during ripening; fig. 1, from green pulp; fig. 2, from yellow-orange pulp; fig. 3, from ripe pulp, showing lycopersicin crystals.

Figs. 4–5. *Aglaonema Treubii:* fig. 4, from green pulp, unstained free-hand sections, mounted in water; fig. 5, ripe juice showing natural lycopersicin crystals.

Figs. 6 and 7. *Solanum Dulcamara.* Unstained, free-hand sections, mounted in water: fig. 6, from yellow-orange pulp; fig. 7, from epicarp of ripe fruit.

Fig. 8. *Dracaena Godseffiana.* Unstained, free-hand sections, mounted in water, from ripe fruit.

Fig. 9. *Evonymus americana.* From unstained smears of pulp of ripe fruit.



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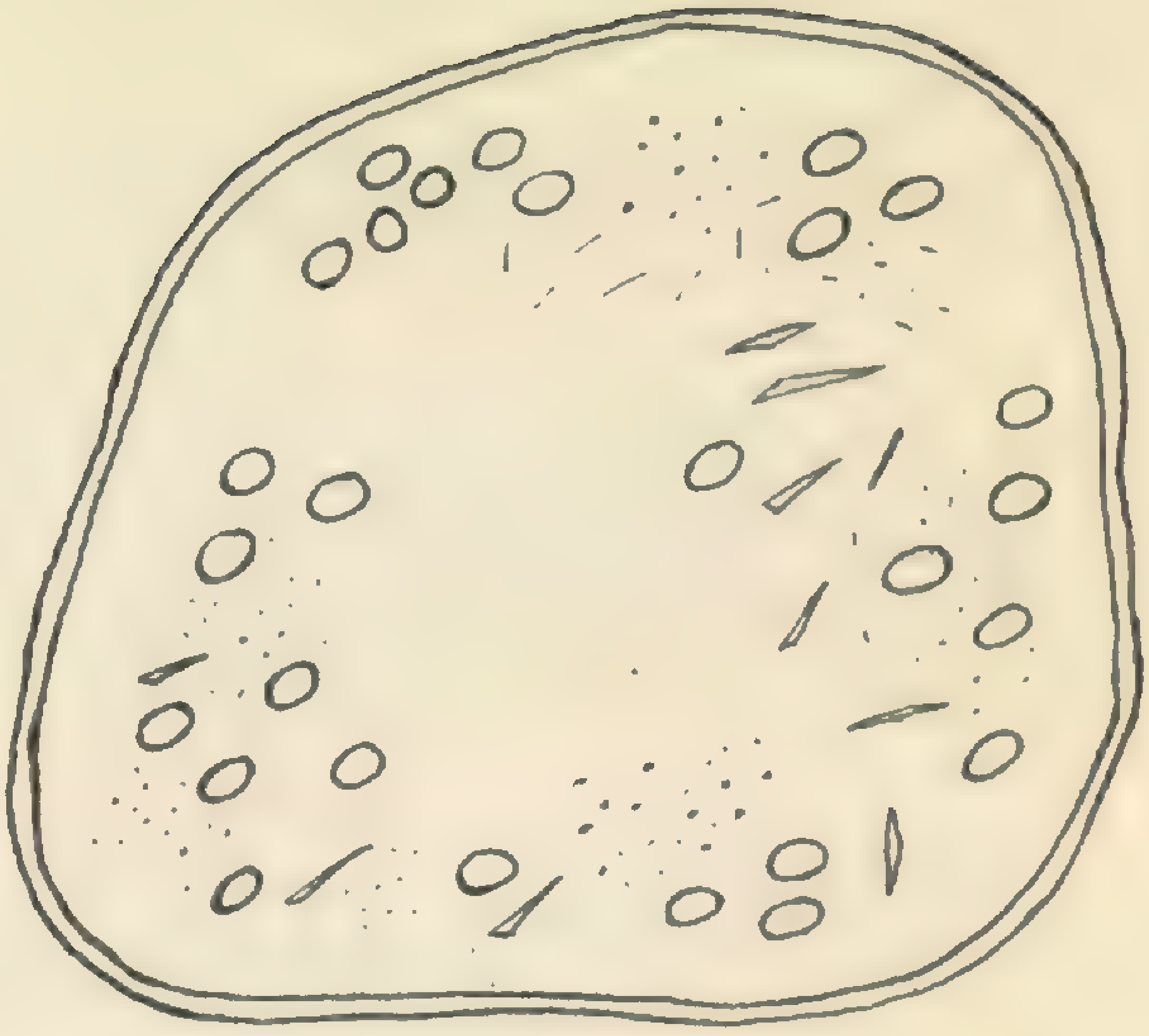

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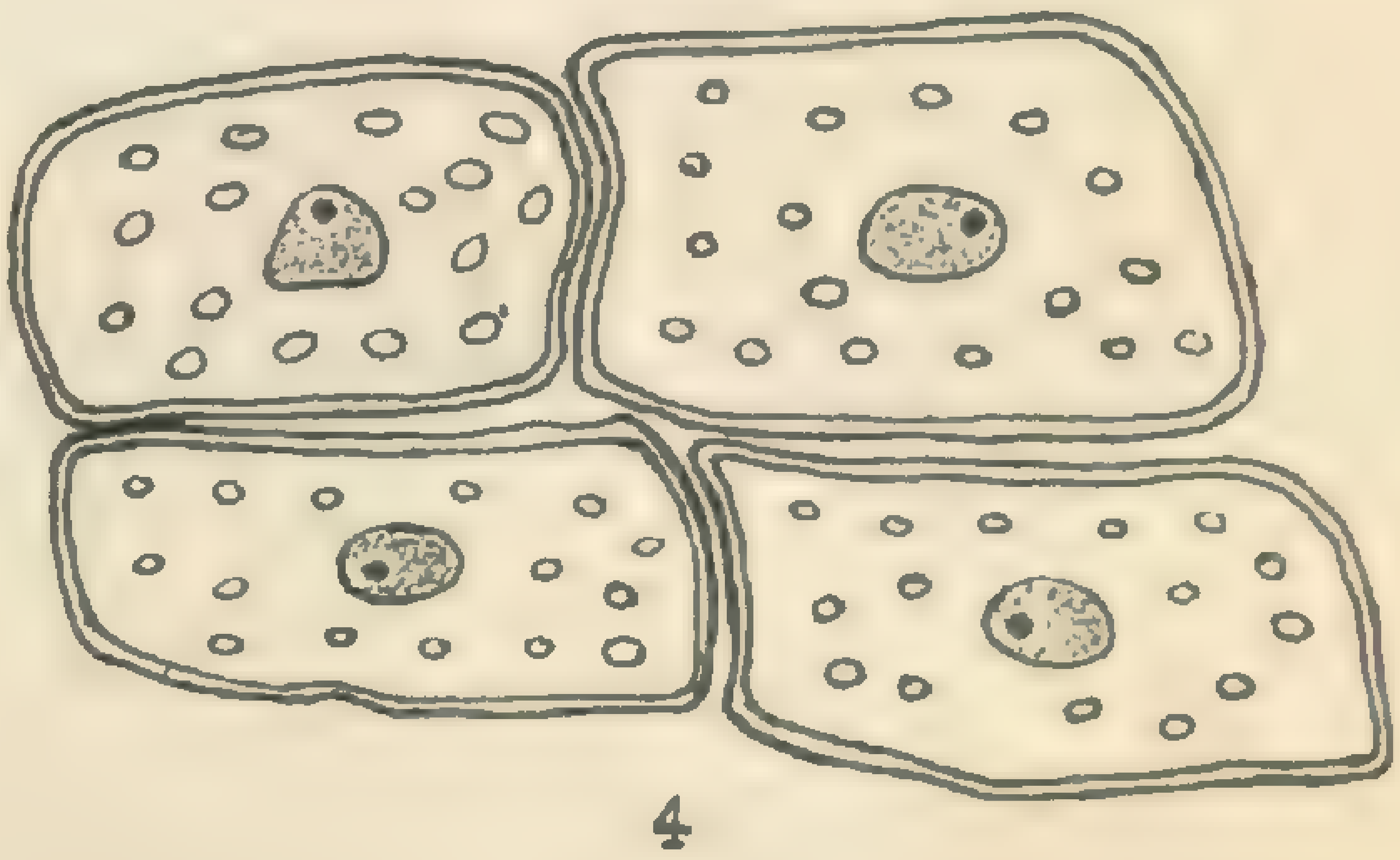

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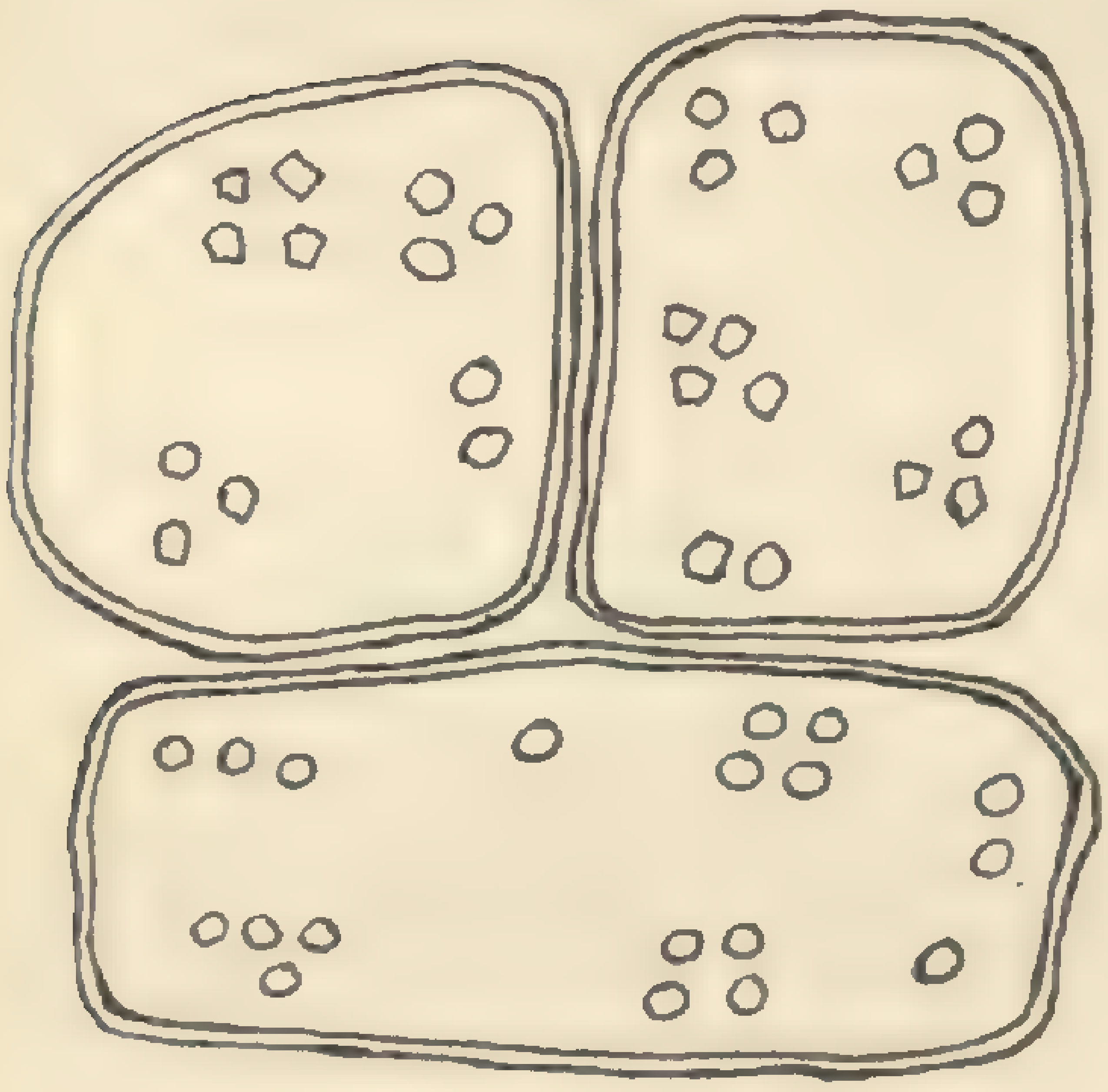

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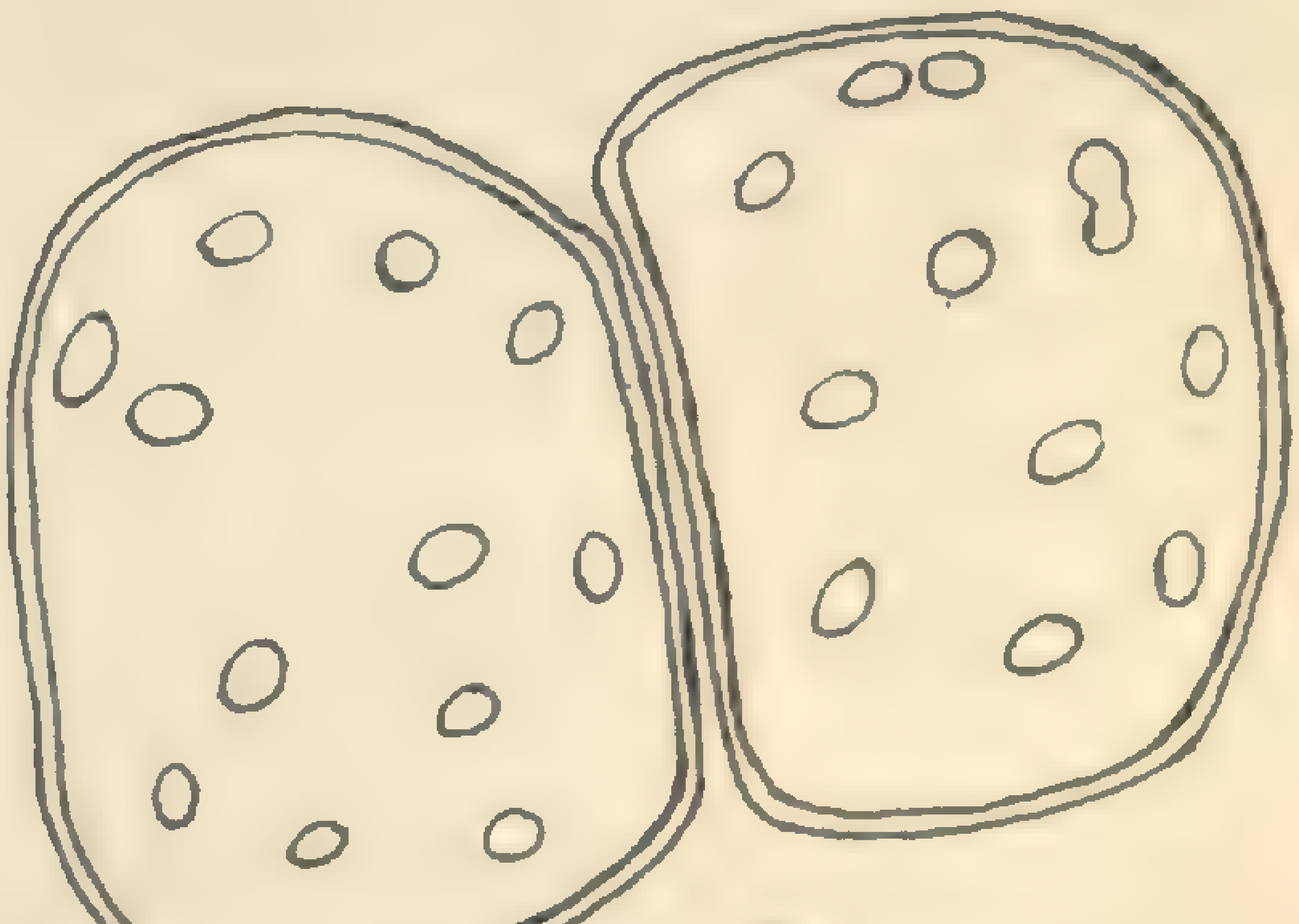

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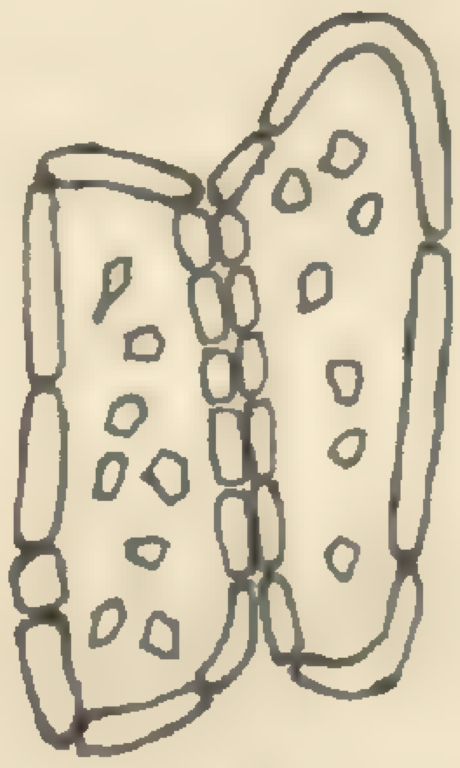

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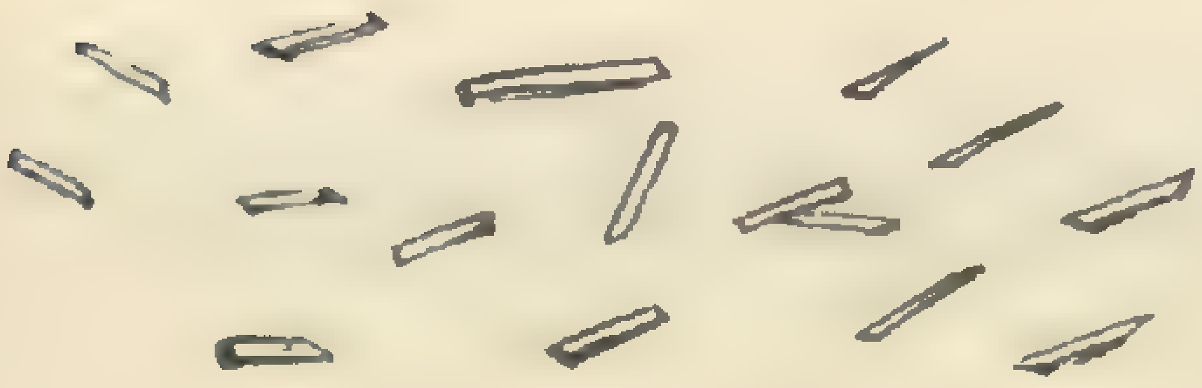

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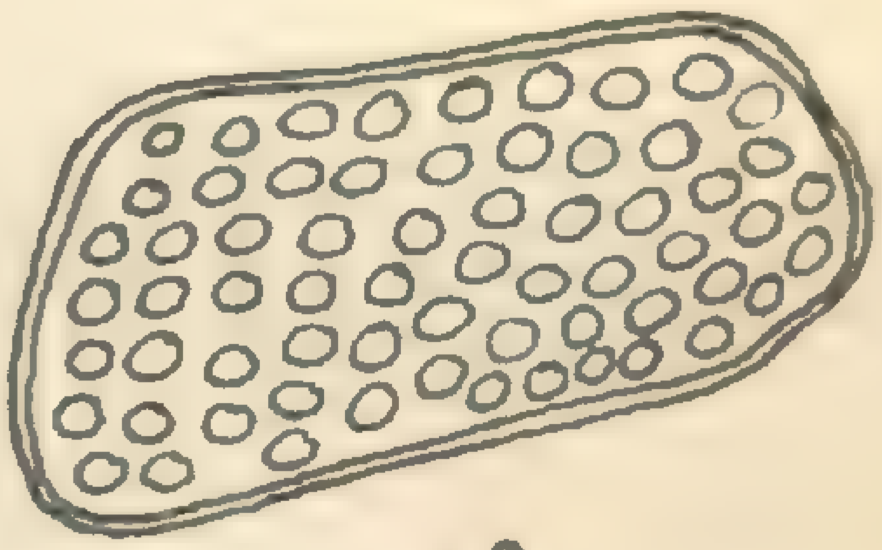


9

HOWARD—CAROTINOIDS IN FRUITS

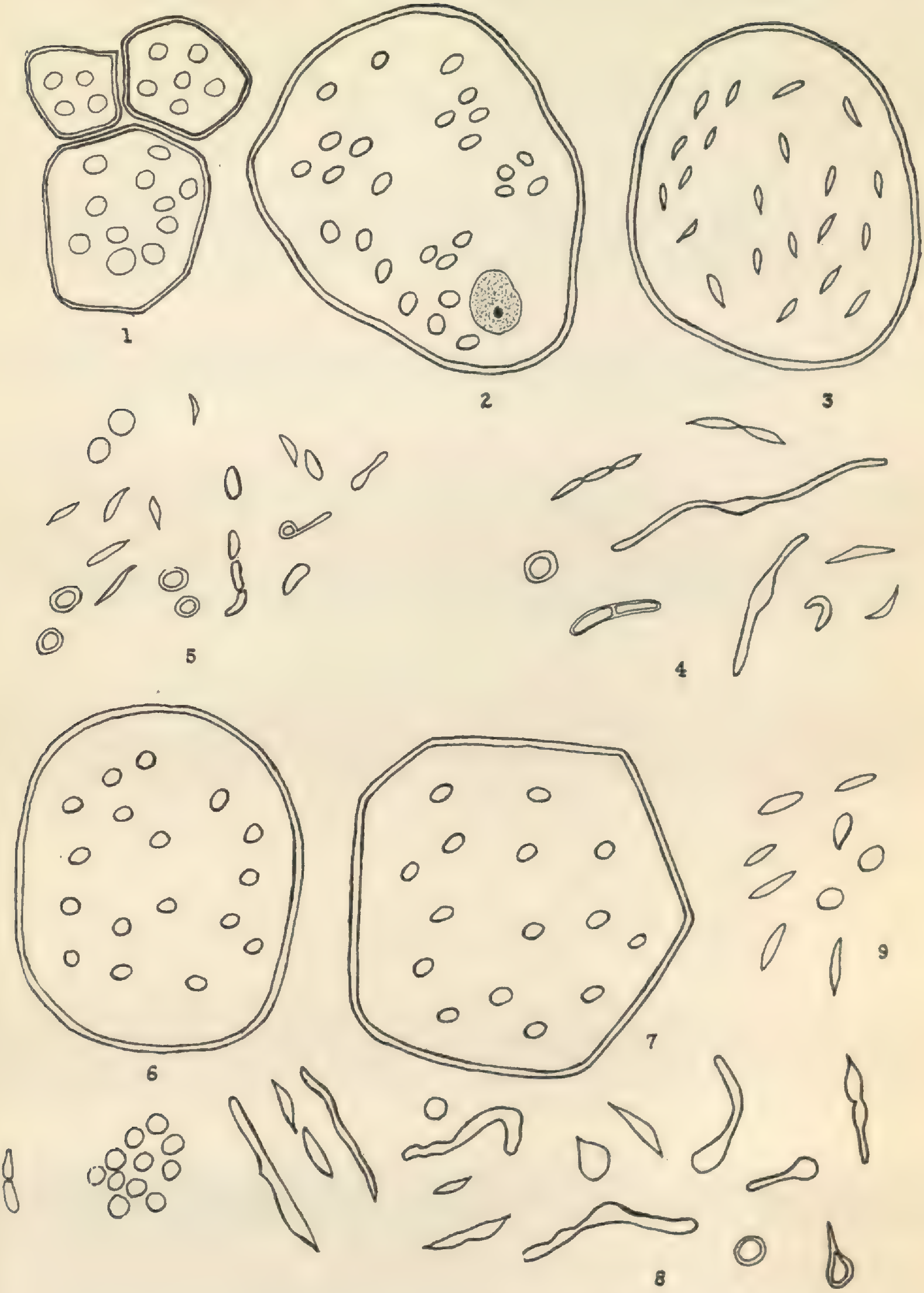
Explanation of Plate

PLATE 12

(Camera-lucida drawings, × 880)

Figs. 1–5. *Lycium halimifolium:* figs. 1–3, successive changes in plastid shapes during ripening; fig. 1, from green pulp; fig. 2, from yellow-orange pulp; fig. 3, from red-ripe pulp; fig. 4, unstained chromoplasts from ripe juice; fig. 5, chromoplasts stained with acid fuchsin from ripe juice.

Figs. 6–9. *Asparagus officinalis:* figs. 6–8, successive changes in plastid shapes during ripening; fig. 6, from green pulp; fig. 7, from yellow-orange pulp; fig. 8, chromoplasts stained with acid fuchsin from ripe juice; fig. 9, from ripe juice.



HOWARD—CAROTINOIDS IN FRUITS

Explanation of Plate

PLATE 13

(Camera-lucida drawings, × 880)

Figs. 1 and 2. *Sorbus sitchensis.* From green and ripe pulp respectively.

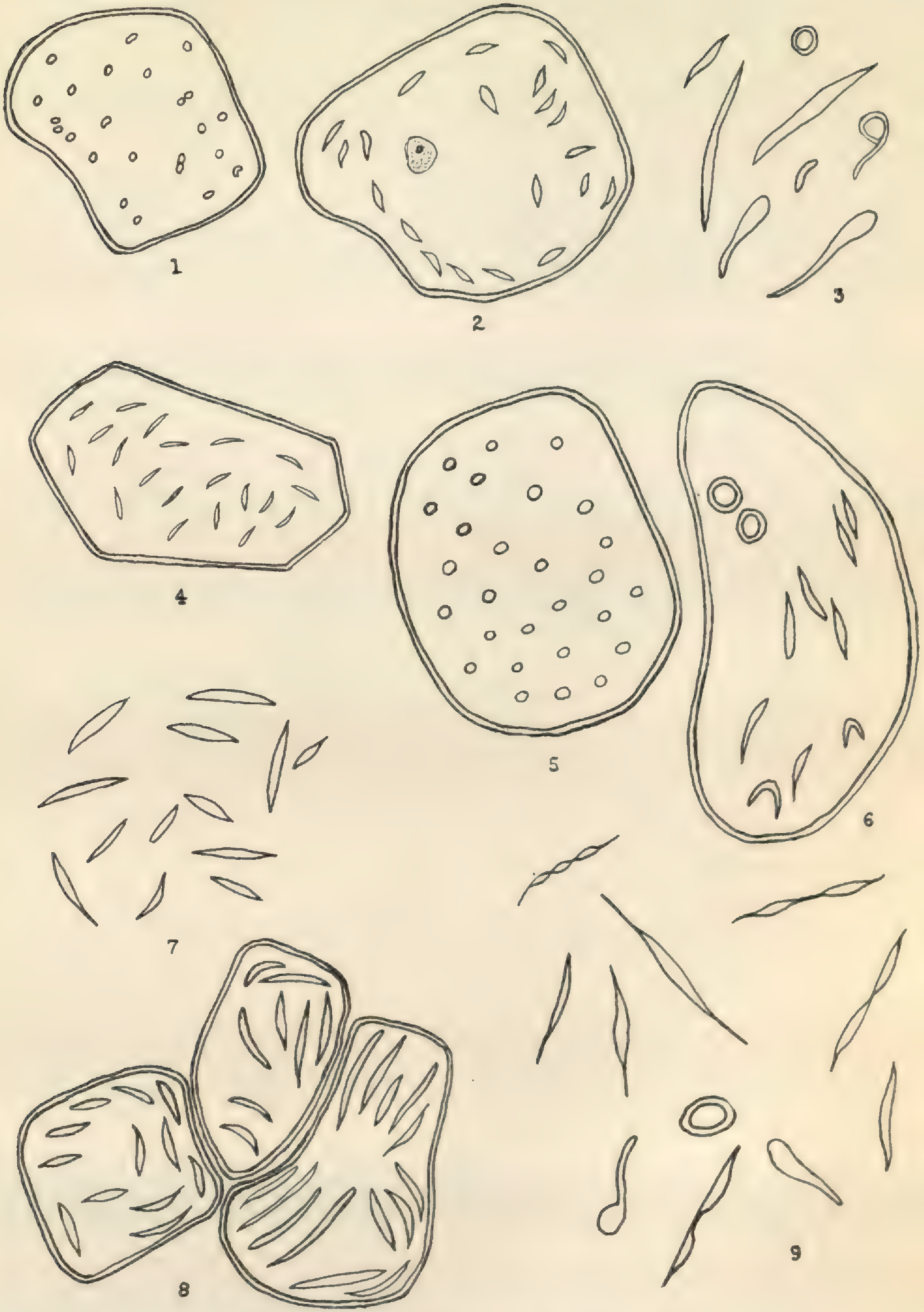
Figs. 3 and 4. *Arisaema triphyllum.* From ripe juice and pulp respectively.

Fig. 5. *Viburnum Opulus.* From ripe pulp.

Fig. 6. *Crataegus phaenopyrum.* From ripe pulp.

Figs. 7 and 8. *Celastrus scandens:* fig. 7, from ripe juice stained with acid fuchsin; fig. 8, from ripe pulp.

Fig. 9. *Solanum Pseudo-capsicum.* From juice of ripe fruit.



HOWARD—CAROTINOIDS IN FRUITS

Explanation of Plate

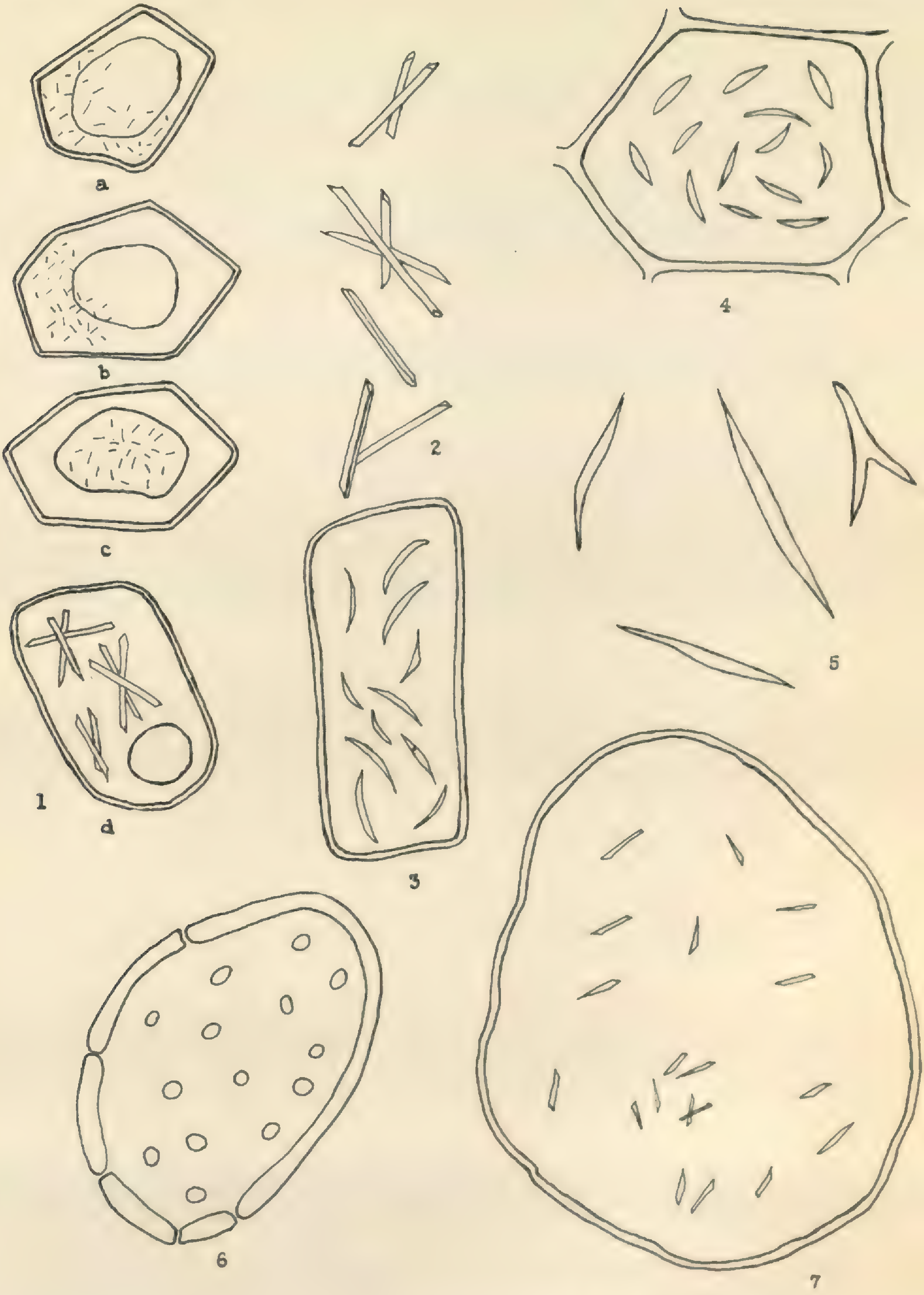
PLATE 14

(Camera-lucida drawings, × 880)

Fig. 1–3. *Evonymus europaea:* fig. 1, a, b, c, and d, successive changes in the formation of crystals by the addition of alcoholic potash in ripe tissue; fig. 2, from ripe fruit showing chromoplasts; fig. 3, crystals obtained by the addition of alcoholic potash.

Figs. 4 and 5. *Lonicera* sp. From pulp and juice respectively of ripe fruit.

Figs. 6 and 7. *Citrullus vulgaris:* fig. 6, from ripe pulp showing lycopersicin crystals; fig. 7, from green portion of pulp, showing chloroplasts.



HOWARD—CAROTINOIDS IN FRUITS

Explanation of Plate

PLATE 15

(Camera-lucida drawings, × 880)

Fig. 1. *Lonicera* sp. Yellow crystals obtained by the addition of alcoholic potash.

Fig. 2. *Lycium halimifolium.* Orange crystals obtained by the addition of glycerine potash.

Fig. 3. *Crataegus phaenopyrum.* Deep red crystals obtained by the addition of glycerine potash.

Fig. 4. *Rhus canadensis.* Carmine-red crystals obtained by the addition of alcoholic potash.

Fig. 5. *Celastrus scandens.* Orange and yellow crystals obtained by the addition of alcoholic potash.

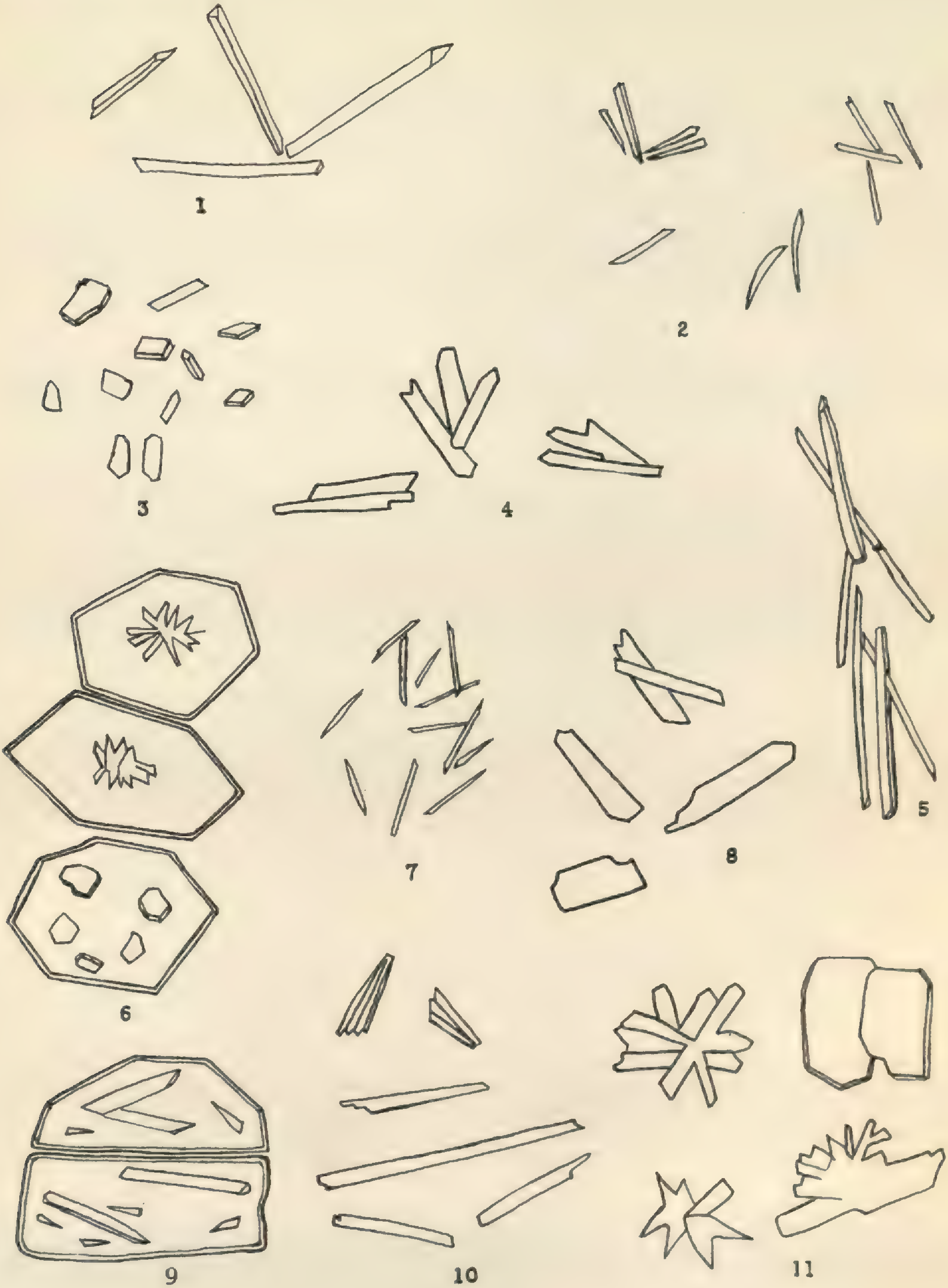
Fig. 6. *Capsicum annuum:* (a) carmine-red crystals obtained by the addition of alcoholic potash; (b) orange crystals obtained by the addition of alcoholic potash.

Fig. 7. *Sorbus sitchensis.* Pale orange crystals obtained by the addition of alcoholic potash.

Fig. 8. *Solanum Dulcamara.* Carmine-red crystals obtained by the addition of alcoholic potash..

Figs. 9 and 10. *Daucus Carota.* Natural carotin crystals.

Fig. 11. *Asparagus officinalis.* Red-orange crystals obtained by the addition of alcoholic potash.



HOWARD—CAROTINOIDS IN FRUITS

Explanation of Plate

PLATE 16

(No camera-lucida drawings)

Daucus Carota

Figs. 1–8. Free-hand sections, unstained, mounted in water from mature root: figs. 1 and 2, from cortex and vascular cylinder respectively, near top of carrot; figs. 3 and 4, from cortex and vascular cylinder respectively, from region just below preceding figures; figs. 5 and 6, from cortex and vascular cylinder respectively, from region just below preceding figures; figs. 8 and 7, from cortex and vascular cylinder respectively, from region nearest tip of root.

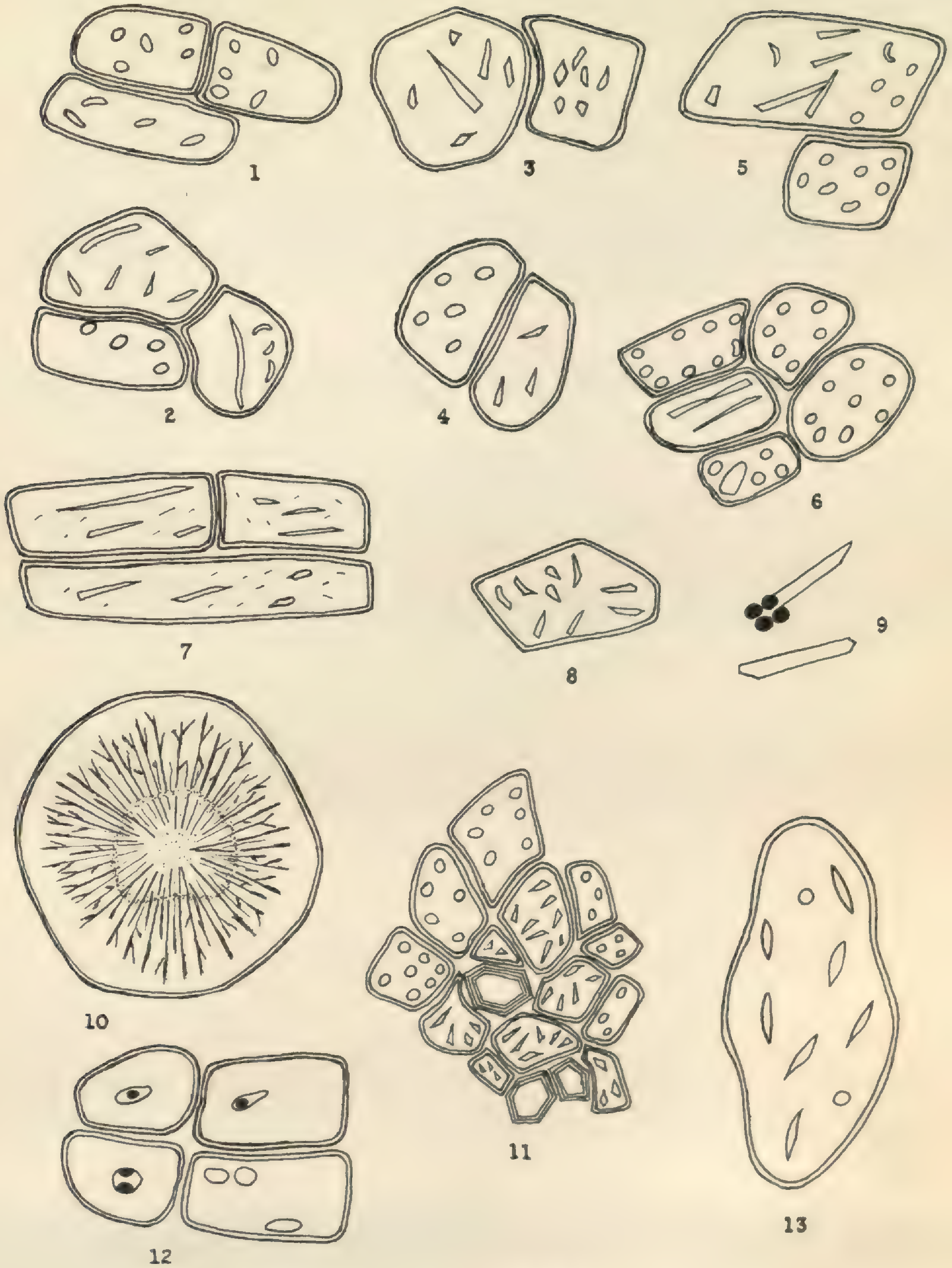
Fig. 9. From young roots, irregularly shaped orange bodies with starch grain inclusions, treated with IKI.

Fig. 10. Cross-section .5 mm. thick, under low power, showing distribution of carotin crystals.

Fig. 11. Cross-section of fibro-vascular bundle in young root, showing plastids and carotin crystals.

Fig. 12. From young root, showing leucoplasts and starch inclusions.

Fig. 13. From young root, showing chloroplasts stained with iron-haematoxylin.



HOWARD—CAROTINOIDS IN FRUITS

Explanation of Plate

PLATE 17

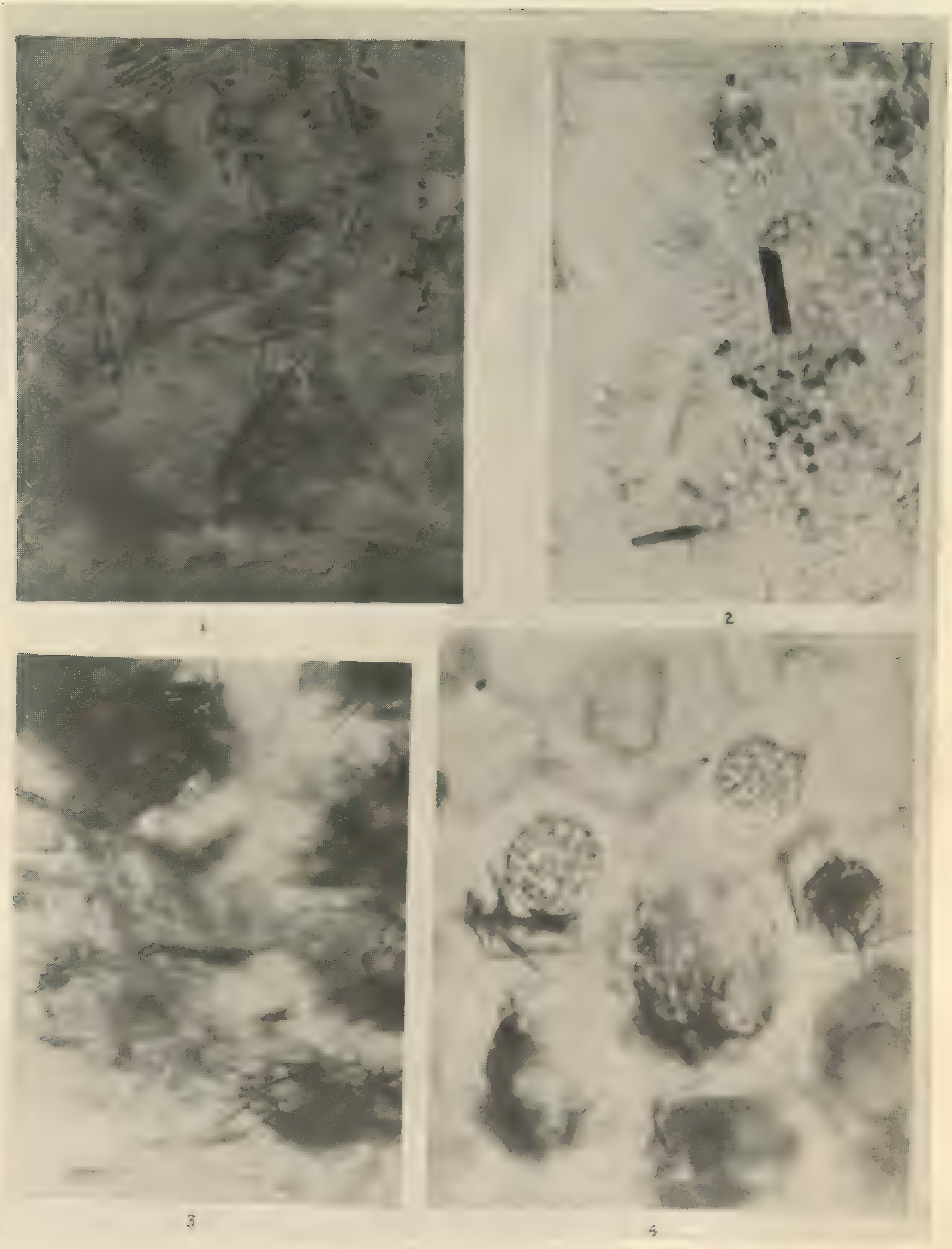
(All photomicrographs, × 800)

Fig. 1. *Solanum Lycopersicum.* Natural lycopersicin crystals in ripe fruit.

Fig. 2. *Solanum Dulcamara.* Lycopersicin crystals obtained by the addition of alcoholic potash.

Fig. 3. *Evonymus americana.* Crystals obtained by the addition of alcoholic potash.

Fig. 4. *Evonymus europaea.* Crystals obtained by the addition of alcoholic potash.



HOWARD—CAROTINOIDS IN FRUITS

Explanation of Plate

PLATE 18

Fig. 1. Dehydrater.

Fig. 2. *Solanum Pseudo-capsicum.* Crystals obtained by the addition of alcoholic potash.

Fig. 3. *Celastrus scandens*, showing chromoplasts, unstained.

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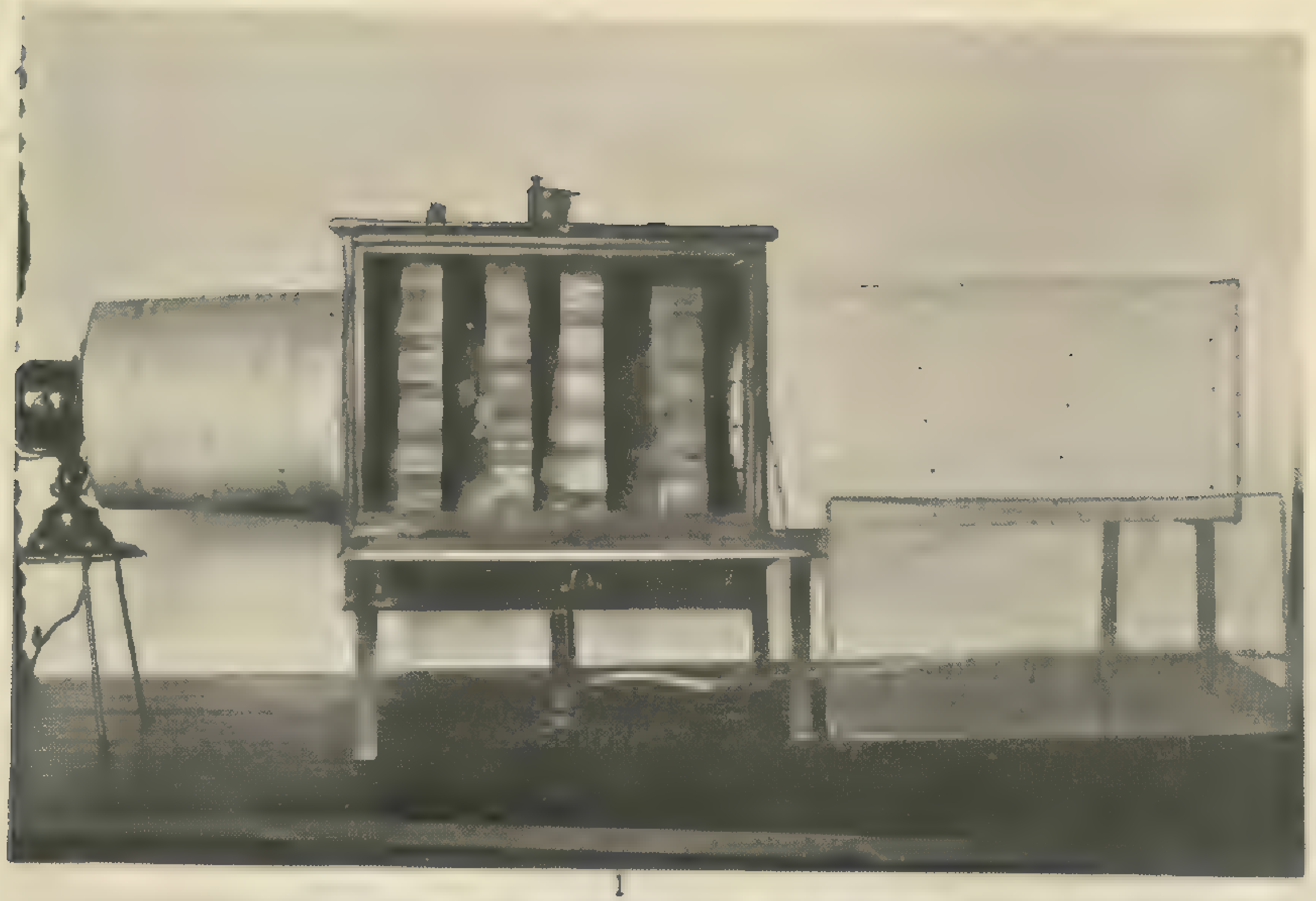

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HOWARD—CAROTINOIDS IN FRUITS

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THE THELEPHORACEAE OF NORTH AMERICA. XIV[1]

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PENIOPHORA

Peniophora Cooke, Grevillea **8**: 20. *pl. 122–125.* 1879; Sacc. Syll. Fung. **6**: 640. 1888; Massee, Linn. Soc. Bot. Jour. **25**: 140. *pl. 47, f. 14–19.* 1889; Karsten, Finska Vet.-Soc. Bidrag Natur och Folk **48**: 421. 1889; Engl. & Prantl, Nat. Pflanzenfam. (**1**:1**): 119. 1898; Bourdot & Galzin, Soc. Myc. Fr. Bul. **28**: 372. 1913; Burt, Mo. Bot. Gard. Ann. **1**: 191, 193, 198. 1914; Rea, Brit. Basid. 687. 1922.—*Kneiffia* (in part) Bresadola, Ann. Myc. **1**: 99. 1903.—Includes *Gloeopeniophora* v. Höhnel & Litschauer, K. Akad. Wiss. Wien Sitzungsber. **116**: 815. 1907. —Includes in part *Gloeocystidium* Karsten, Finska Vet.-Soc. Bidrag Natur och Folk **48**: 429. 1889.

Fructifications waxy, coriaceous, cartilaginous, membranaceous, submembranaceous, floccose, or filamentous, always resupinate, effused, even; simple basidia with 2–4 white spores; cystidia incrusted or not incrusted, present in the hymenium and often more or less immersed in the substance; substance variously differentiated in some species but not containing colored, stellate organs.—Distinguished from *Corticium* by the presence of cystidia.

The North American species of *Peniophora* are here arranged in five groups according to the color of the substance of the fructification, nature of the cystidia, and presence or absence of gloeocystidia. These groups are further subdivided to such degree as

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seems desirable by color of hymenium, adnation to substratum, and incrustation of cystidia or of hyphae, into minor groups of so few species that the characters of the component species of any group within which a species seems to belong, may all be considered in determining the probable species of the specimen in course of identification. An appalling amount of time and labor has been required for the accumulation from sectional preparations of the structural characters of the individual specimens of species of *Peniophora* listed in this work. The older descriptions of resupinate Hymenomycetes were based on so few definite characters that a specimen in hand might seem to be referable equally well to more than one published species, or that several specimens in hand and certainly different specifically might all seem referable to one species, judging from its published description. However, by the addition of the knowledge of the definite features of structure characteristic of species, determining additional characters have been found for so many species that the specific taxonomy of the large genus *Peniophora* in North America becomes practicable. In the use of this work sectional preparations of fertile specimens are necessary.

Of the 120 species of *Peniophora* described herein, 36 occur in Europe as well as in North America and 11 others have been already recognized as North American species. The remaining 73 species are unlike those which the writer has been able to recognize among the known species from other regions of the world and have therefore to be described as new. It is quite probable that nearly all of these 73 species will bear the test of study by foreign mycologists and be demonstrated eventually to be really new, for most of them are of local occurrence, known from a single collection and distributed with surprising uniformity over the great area of North America which has in its different regions such great differences in temperature, moisture, altitude, and composition of its forests that the conditions are ideal for the origin and survival of species of merely local distribution. This is in accord with the fact that 9 of our new species occur in more than one state and that others occur as follows:—7 from Louisiana; 4 each from New York, British Columbia, Washington, Mexico, and Jamaica; 3 each from Vermont, Idaho, Oregon,

and Texas; 2 each from Canada, New Hampshire, Alabama, Florida, Colorado, and Porto Rico; and 1 each from Virginia, Georgia, Kentucky, Montana, Alaska, California, New Mexico, Nicaragua, Cuba, and Bermuda.

It might be well for American students who use this work for the determination of their gatherings of *Peniophora* to concentrate their attention in first attempts on the characters of the species of wide distribution and on such of the new species as are local in their respective regions.

Mycologists, with special knowledge of the *Thelephoraceae* in every nation, work not only to make better known the fungous floras of their own countries, but also to determine which of their species occur in other countries. As an aid to such study in the future and for checking my work, there is here given the following list of foreign species of *Peniophora*, not known to me except from the more or less satisfactory published descriptions, viz., *Peniophora abietis, P. amaniensis, P. atro-cinerea, P. avellanea, P. bambusicola, P. carneola, P. Cheesmanii, P. cineracea, P. citrina, P. coccinea, P. Coffeae, P. convolvens, P. Corsica, P. crustosa, P. diffissa, P. discoidea, P. Dussii, P. fimbriata, P. gigaspora, P. habgallae, P. leprosa, P. lilacea, P. Martelliana, P. mimica, P. ochroleuca, P. orphanella, P. pirina, P. rimicola, P. rufomarginata, P. sordidella, P. sororia, P. sparsa, P. subavellanea, P. subglebulosa, P. sublaevis, P. subtilis, P. tomentella, P. tremelloidea,* and *P. vermicularis.* It is probable that most of these species are of local interest but I should like to have been sure that I have not redescribed any of them as new American species. Much time and effort have been required to make this list as small as it is.

Key to Arrangement of the Species

I. Substance not colored, with the usual cystidia, no gloeocystidia.
 1. Hymenium white or whitish.
  *At least small pieces separable when moistened.
   a. Cystidia incrusted *1–7*
   b. Cystidia not incrusted *8, 9*
  **Closely adnate, not separable.
   a. Antler-shaped paraphyses not present.
    †Cystidia incrusted *10–13*
    ††Cystidia rough-walled or denticulate *14, 15*
    †††Cystidia not incrusted, even *16–24*
   b. Antler-shaped paraphyses present *25–27*

2. Hymenium colored and the subhymenium also in a few species.
 *Closely adnate, not separable.
  a. Cystidia not incrusted.
   †Fructification not stratose........................ *28–30*
   ††Fructification becoming stratose.................. *31, 32*
  b. Cystidia incrusted.................................. *33–38*
 **At least small pieces separable when moistened.
  a. Cystidia incrusted.
   †Hyphae incrusted................................... *39–44*
   ††Hyphae not incrusted or not obviously incrusted...... *45–52*
  b. Cystidia not incrusted.
   †Hyphae incrusted................................... *53–56*
   ††Hyphae not incrusted or not obviously incrusted.... *57–61*

II. Substance not colored almost without exception, cystidia very long, cylindric, thick-walled, not normally incrusted, often visible through whole thickness of the fructification, no gloeocystidia—the *P. glebulosa* group................................. *62–68*

III. Substance not colored, gloeocystidia present as well as cystidia—the gloeocystidial group.
 1. At least small pieces separable when moistened.
  *Cystidia incrusted.
   †Some cystidia 40–100 × 20–50 µ......................... *69*
   ††Cystidia of the usual size........................... *70–79*
  **Cystidia not incrusted................................. *80–83*
 2. Closely adnate, not separable........................ *84–90, 111*

IV. Substance yellow or yellowish rather than dark-colored and often bleached by potassium hydrate solution.
 1. At least small pieces separable when moistened............... *91–97*
 2. Closely adnate, not separable............................ *98–100*

V. Substance more or less dark-colored, the dark color retained in preparations stained with eosin. Gloeocystidia sometimes present.
 1. Fructification stratose................................. *101–102*
 2. Fructification not stratose.
  *At least small pieces separable when moistened. Compare also resupinate *Stereum ferreum*............................ *103–110*
  **Closely adnate, not separable.......................... *111–120*
   (Including as 117–120 the *P. cinerea* group with opaque zone next to substratum and the largest cystidia on this zone.)

1. Peniophora gigantea (Fr.) Massee, Linn. Soc. Bot. Jour. **25:** 142. Je. 1889; Karsten, Finska Vet.-Soc. Bidrag Natur och Folk **48:** 422. 1889; Bresadola, I. R. Accad. Agiati Atti III. **3:** 113. 1897; Bourdot & Galzin, Soc. Myc. Fr. Bul. **28:** 401. 1913; Rea, Brit. Basid. 693. 1922.

Thelephora gigantea Fries, Obs. Myc. **1:** 152. 1815; Syst. Myc. **1:** 448. 1821.—*Corticium giganteum* Fries, Epicr. 559. 1838; Hym. Eur. 648. 1874; Peck, N. Y. State Mus. Rept. **28:** 52. 1876; Sacc. Syll. Fung. **6:** 610. 1888.

Illustrations: Fries, Icones Hym. **2**: *pl. 197, f. 3.*

Fructifications broadly effused, hyaline, white, waxy, swelling when moist and separable from substratum, when dry horn-like and parchment-like, the hymenium even, pale pinkish buff, pale olive-buff, or pallid mouse-gray in the herbarium, the margin white, fibrillose, radiating, sometimes becoming free and curling away from the substratum in drying; in section 100–500 μ thick, not colored, with the broad layer towards the substratum composed of crowded and more or less longitudinally arranged hyphae so highly gelatinously modified that only the lumen and cell contents usually show distinctly in preparations, about 3–5 μ in diameter; cystidia incrusted, about 40–50 × 8–12 μ, confined to the hymenium or a zone up to 100 μ broad; spores hyaline, even, about 4½–5 × 2½–3 μ as found in preparations.

Fructifications 3–30 cm. in diameter.

On bark and wood of dead conifers such as *Pinus*, *Abies*, and *Tsuga.* In Europe, Canada to Texas, westward to the Pacific states, in Mexico, and in Japan. June to January. Widely distributed and abundant locally.

P. gigantea may usually be recognized at sight by its occurrence on coniferous bark in large, whitish or pinkish buff fructifications of cartilaginous structure, separable from the substratum and more or less curling away from it in drying.

Specimens examined:

Exsiccati: Bartholomew, Fungi Col., 2422, 4242, 4622; Ellis, N. Am. Fungi, 410; Krieger, Fungi Sax., 117; Ravenel, Fungi Am., 452; Fungi Car. **2**: 38; Romell, Fungi Scand., 34; Sydow, Myc. Germ., 553; de Thümen, Myc. Univ., 909.

Finland: Mustiala, *P. A. Karsten*, in Myc. Univ., 909.

Sweden: *L. Romell, 97, 98, 349,* and in Romell, Fung. Scand., 34.

Germany: Brandenburg, *H. Sydow*, in Sydow, Myc. Germ., 553; Königstein, *W. Krieger*, in Krieger, Fungi Sax., 117.

Austria: Karwendel, Tirol, *V. Litschauer;* Stubai, Tirol, *V. Litschauer.*

Italy: Trient, *G. Bresadola.*

France: *Fautrey*, comm. by Lloyd Herb., 4354; Jura, *N. Patouillard* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 55907).

Canada: Montreal, on timbers in a mill, *R. J. Blair, 337*, comm. by L. O. Overholts, 4113 (in Mo. Bot. Gard. Herb., 55632); Belleville, Ontario, *J. Macoun, 253;* Ottawa, *J. Macoun, 48.*

New Hampshire: Chocorua, *W. G. Farlow, 32.*

Massachusetts: Fall River, on floor beams in a mill, *W. H. Snell* (in Mo. Bot. Gard. Herb., 57379).

New York: ex herb. Torrey, 112 (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61437); Beaver River, Adirondacks, *G. F. Atkinson, 4606;* Mechanicville, *C. H. Peck* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 55575).

New Jersey: Newfield, *J. B. Ellis*, in Ellis, N. Am. Fungi, 410.

Pennsylvania: Adelaide, on cross ties, *H. v. Schrenk* (in Mo. Bot. Gard. Herb., 6685); State College, *L. O. Overholts, 4810* (in Mo. Bot. Gard. Herb., 56124).

Maryland: Takoma Park, *C. L. Shear, 1266*, and in Bartholomew, Fungi Col., 2422.

Virginia: Rio, *F. Gravatt* (in Mo. Bot. Gard. Herb., 44042).

North Carolina: Biltmore, *E. Bartholomew, 5658* (in Mo. Bot. Gard. Herb., 44216), and in Bartholomew, Fungi Col., 4622; Chapel Hill, *J. N. Couch*, comm. by Univ. N. C. Herb., 4306 (in Mo. Bot. Gard. Herb., 57422).

South Carolina: *H. W. Ravenel*, in Ravenel, Fungi Car. **2**: 38; Aiken, *H. W. Ravenel*, in Ravenel, Fungi Am., 452.

Georgia: Brunswick, *H. v. Schrenk* (in Mo. Bot. Gard. Herb., 43887).

Florida: *W. W. Calkins, 63* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61446).

Louisiana: Shreveport, *E. Bartholomew*, in Bartholomew, Fungi Col., 4242, and (in Mo. Bot. Gard. Herb., 4943).

Texas: Houston, *H. W. Ravenel, 221;* Quitman, *W. H. Long, 12074*, and comm. by C. J. Humphrey, 2552 (in Mo. Bot. Gard. Herb., 55046 and 9804 respectively); Somerville, *H. v. Schrenk* (in Mo. Bot. Gard. Herb., 42884).

Michigan: Bay City, *J. R. Weir, 301* (in Mo. Bot. Gard. Herb., 20143).

Wisconsin: Madison, on log of *Pinus Taeda* in timber yard, *M. C. Jensen*, comm. by C. J. Humphrey, 719 (in Mo. Bot. Gard. Herb., 42729).

Minnesota: Cass Lake, *J. R. Weir, 394* (in Mo. Bot. Gard. Herb., 13981); St. Louis River, *J. C. Arthur, L. H. Bailey & E. W. D. Holway, 175 St.* (in Mo. Bot. Gard. Herb., 4821).

Arkansas: Texarkana, on cross ties, *H. v. Schrenk* (in Mo. Bot. Gard. Herb., 56378).

Colorado: Tolland, *L. O. Overholts, 1834* (in Mo. Bot. Gard. Herb., 54879).

Montana: Libby, *E. E. Hubert*, comm. by J. R. Weir, 11449 (in Mo. Bot. Gard. Herb., 63276); Rockhill, *E. E. Hubert*, comm. by J. R. Weir, 11966, 11979, 11984 (in Mo. Bot. Gard. Herb., 63336–8).

Idaho: Coolin, *J. R. Weir, 11097*, comm. by U. S. Dept. Agr., Path. Myc. Coll., 1335 (in Mo. Bot. Gard. Herb., 62988); Priest River, *J. R. Weir, 80* (in Burt Herb.) and *5825, 6331, 11985, 12018, 14938* (in Mo. Bot. Gard. Herb., 58289, 55950, 63350, 63374, and 56800 respectively); Santa, *E. E. Hubert*, comm. by J. R. Weir, 11603 (in Mo. Bot. Gard. Herb., 63304).

British Columbia: Hastings, *J. Macoun, 24*.

New Mexico: Gila National Forest, *G. G. Hedgcock & W. H. Long*, comm. by C. J. Humphrey, 2524 (in Mo. Bot. Gard. Herb., 21669).

Mexico: Orizaba, Nuevo, *W. A. & E. L. Murrill, 767*, comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 54649).

Japan: Sendai, *A. Yasuda, 76* (in Mo. Bot. Gard. Herb., 56315).

2. P. globifera Ellis & Everhart, Am. Nat. **1897**: 340. 1897; Sacc. Syll. Fung. **14**: 224. 1899.

Type: in N. Y. Bot. Gard. Herb. and a fragment in Burt Herb.

Fructifications broadly effused, separable when moistened, when dry horn-like, whitish to pale smoke-gray, the hymenium with somewhat convex granules, bristling with the crowded cystidia; in section 400–500 μ thick, not colored, with a layer about 200–300 μ thick towards the substratum composed wholly of densely interwoven, hyaline hyphae 3–5 μ in diameter, with the walls so gelatinously modified as to be very indistinct; no gloeocystidia; cystidia heavily and coarsely incrusted, 30–70 × 12–15 μ, very abundant both in the hymenium and im-

mersed throughout an outer zone up to 150 μ thick; basidiospores hyaline, even, 4–6 × 2–2½ μ.

Fructifications up to 10 cm. in diameter.

On bark of conifers. New York and Ontario, and in Montana, Idaho, British Columbia, Oregon, and New Mexico. August to October. Rare.

P. globifera is either known only from the type collection or else it is an extreme form of *P. gigantea,* for each of the more recent gatherings cited below has some character approaching *P. gigantea.* The distinctive features of the type of *P. globifera* are whiter color, much more numerous and larger cystidia which are also more coarsely incrusted, and a hymenial surface with some convex granules like those of *Grandinia granulosa.* The original description is erroneous in stating that the fructifications are closely adnate and that the spores are globose and 3 μ in diameter.

Specimens examined:

Ontario: Ottawa, McKay's Lake, *J. Macoun, 175,* type (in N. Y. Bot. Gard. Herb.) and a specimen from the type collection, comm. by J. Macoun; Harraby, *E. T. & S. A. Harper, 680;* St. Lawrence Valley, *J. Macoun, 85.*

New York: Mt. McIntyre, *C. H. Peck* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 55777).

Montana: Rockhill, *E. E. Hubert,* comm. by J. R. Weir, 11960 (in Mo. Bot. Gard. Herb., 63317).

Idaho: Coolin, *J. R. Weir, 11158M, 11491* (in Mo. Bot. Gard. Herb., 63254, 63279); Priest River, *J. R. Weir, 20.*

British Columbia: Kootenai Mts. near Salmo, *J. R. Weir, 517, 525* (in Mo. Bot. Gard. Herb., 5068, 19430).

Oregon: Portland, *C. J. Humphrey, 6126.*

New Mexico: Cloudcroft, *W. H. Long, 19524* (in Mo. Bot. Gard. Herb., 44765).

3. **P. arachnoidea** Burt, n. sp.

Type: in N. Y. Bot. Gard. Herb. and Burt Herb.

Fructifications effused, very thin, fragile, small pieces separable, white, becoming cartridge-buff in the herbarium, the hymenium continuous, not shining, fragile, loosely supported on an arachnoid subiculum, the margin delicately fibrillose or arach-

noid; in section 150–300 μ thick, not colored, 2-layered, with the layer next to the substratum composed of very loosely arranged, nodose-septate, hyaline hyphae 3–4 μ in diameter and with the hymenial layer about 50 μ thick, compact; no gloeocystidia; cystidia numerous, tapering, rough or granule-incrusted near the tips, 4–6 μ in diameter, protruding up to 40 μ beyond the basidia; spores hyaline, even, 3–4 × 2–2½ μ, copious.

Fructifications 1–4 cm. in diameter.

On bark of fallen limbs of *Populus* and *Alnus*. New Hampshire, New York, Alabama, and Oregon. October and November. Rare.

P. arachnoidea has the aspect of *Corticium arachnoideum* but is a *Peniophora*. The hyphae and their arrangement are like those of *P. cremea*. The microscopic characters are so similar to those of *Coniophora byssoidea* that the gatherings from northern localities may possibly be white forms of the latter which I have erroneously included under *P. arachnoidea*.

Specimens examined:

New Hampshire: Hanover, on *Populus*, *G. R. Lyman*, *27* (in N. Y. Bot. Gard. Herb., Mo. Bot. Gard. Herb., 61589, and Burt Herb.).

New York: Ithaca, *G. F. Atkinson*, *2589*, formerly referred by me to *C. byssoidea;* Karner, on *Populus*, *H. D. House* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 54376).

Alabama: Auburn, on *Alnus*, *F. S. Earle*, *97*, type, comm. by N. Y. Bot. Gard. Herb.; Montgomery County, *R. P. Burke*, *367* (in Mo. Bot. Gard. Herb., 57234).

British Columbia: Salmo, *J. R. Weir*, *472*, *480* (in Mo. Bot. Gard. Herb., 63357, 63387).

Oregon: White Pine, on hymenium of *Thelephora terrestris*, *J. R. Weir*, *620* (in Mo. Bot. Gard. Herb., 13999).

4. **P. inconspicua** (B. & C.) Massee, Linn. Soc. Bot. Jour. **25**: 149. *pl. 47, f. 14.* 1889; Sacc. Syll. Fung. **21**: 410. 1912.

Corticium inconspicuum Berkeley & Curtis, Linn. Soc. Bot. Jour. **10**: 336. 1868; Sacc. Syll. Fung. **6**: 615. 1888.

Type: in Kew Herb. and Curtis Herb.

Fructifications effused, thin, small, orbicular, gregarious, becoming confluent, membranaceous, small pieces separable, white

when fresh, becoming light buff in the herbarium, even, setulose with the cystidia, the margin composed of radiating hyphae; in section 250–300 μ thick, not colored, composed of densely interwoven, rather thick-walled and rigid, ascending hyphae 3–4 μ in diameter, not incrusted; no gloeocystidia; cystidia incrusted, fusoid, 50–60 × 12–15 μ, scattered in the surface of the hymenium; spores in a crushed preparation are hyaline, even, 4 × 3 μ, so few that they may not belong.

Fructifications about 2 mm. in diameter, becoming more or less confluent over areas up to 3 cm. long and 1 cm. wide.

On bark of dead frondose limbs. West Indies. December and March.

P. inconspicua has small clustered fructifications becoming confluent and very large cystidia scattered along the surface of the hymenium and none wholly immersed. In one portion of my sections the hyphae next to the substratum are slightly brownish and suggestive of those of a resupinate *Stereum* but I do not recall an effuso-reflexed *Stereum* of which *P. inconspicua* may be the resupinate fructification.

Specimens examined:

Cuba: Mountain of Rangel, *C. Wright*, Fungi Cubenses Wrightiani, 841, type (in Kew Herb., Curtis Herb., Mo. Bot. Gard. Herb., Burt Herb., and an unnumbered portion in N. Y. Bot. Gard. Herb.).

Porto Rico: Rio Piedras, *J. R. Johnston, 1664*, comm. by J. A. Stevenson (in Mo. Bot. Gard. Herb., 13223).

5. **P. galochroa** Bresadola, Hedwigia **35**: 200. 1896; Sacc. Syll. Fung. **14**: 224. 1899.

Type: a part in Burt Herb.

Broadly effused, membranaceous, small pieces separable, from white becoming pinkish buff, finally cracked and silky along the crevices, the margin somewhat fimbriate at first, soon similar; in section 250–400 μ thick, not colored, with hyphae rather stiff, thick-walled, 2–2½ μ in diameter, not incrusted, not nodose-septate, longitudinally arranged in a thin layer next to the substratum, densely interwoven in the broad middle region, the hymenial layer about 50 μ thick; no gloeocystidia; cystidia coarsely

incrusted, fusiform, 25–50 × 9–10 μ, barely protruding, usually immersed in all parts of the hymenial layer; spores published by Bresadola as 5½–6½ × 4–4½ μ but I find the type sterile.

Fructifications 3–6 cm. long, 1½–2½ cm. wide.

On bark of decaying branches and on wood. Brazil and West Indies. August to December. Rare.

In aspect *P. galochroa* is somewhat suggestive of *Corticium portentosum* but much thinner and very different in structure by the presence of cystidia which are confined to a hymenial layer not more than 50 μ thick in the specimens studied. The specimens from the West Indies, which I have referred to *P. galochroa*, have subglobose spores about 3 μ in diameter and are perhaps a distinct species if *P. galochroa* has as large spores as published by Bresadola, but I find the portion of the type communicated to me wholly sterile.

Specimens examined:

Brazil: Blumenau, *A. Möller*, type, from Bresadola.

Jamaica: Chester Vale, *W. A. & E. L. Murrill, 331, 751*, comm. by N. Y. Bot. Gard. Herb.

Porto Rico: Rio Piedras, *J. A. Stevenson, 2985* (in Mo. Bot. Gard. Herb., 7799).

6. P. odontioides Burt, n. sp.

Type: in Mo. Bot. Gard. Herb.

Fructifications effused, very thin, arachnoid-membranaceous, tender, small pieces separable when moistened, white, even, not shining, the margin thinning out, fibrillose; in section 50–130 μ thick, not colored, composed of thin-walled, loosely interwoven, suberect hyphae about 4–4½ μ in diameter, incrusted, becoming collapsed; no gloeocystidia; cystidia of *Odontia* type, transversely septate, cylindric-obtuse, 8 μ in diameter, protruding up to 45 μ, not incrusted or with a few incrusting granules; spores hyaline, even, 9–12 × 4–4½ μ, copious.

Fructifications in fragments which are 2–3 cm. long, 5–6 mm. wide.

On decaying frondose wood. Canada. July to September.

P. odontioides is distinguished among our thin, white species by having large, cross-septate cystidia such as are common in

many species of *Odontia* where they are clustered together in the granules, but in the present species such cystidia are distributed along an even hymenium devoid of granules.

Specimens examined:

Canada: *J. Macoun, 20;* St. Lawrence Valley, *J. Macoun, 14.*

Manitoba: 52° 15′ north latitude, Swan River, *G. R. Bisby, 1047,* type (in Mo. Bot. Gard. Herb., 59034).

7. **P. exigua** Burt, n. sp.

Type: in Mo. Bot. Gard. Herb. and N. Y. Bot. Gard. Herb.

Fructifications effused, small, circular, gregarious, thin, somewhat membranaceous, tender, small pieces separable when moistened, snow-white, even, contracting in drying and cracking into polygonal masses 1–2 mm. in diameter, with the white arachnoid subiculum visible on the sides of the fissures, the margin narrow, white, arachnoid; in section 150–180 μ thick, not colored, with some hyphae densely arranged parallel with the substratum and then ascending and loosely interwoven to the hymenial layer, about 3 μ in diameter, thin-walled, not nodose-septate, perhaps slightly incrusted in the hymenial layer; no gloeocystidia; cystidia incrusted, cylindric, 30–60 × 6–7 μ, confined to the hymenial layer and usually wholly immersed, a few protruding up to 12 μ beyond the basidia; spores hyaline, even, 4–5 × 2½ μ.

Fructifications 1–12 mm. in diameter—8 in an area 4 × 1 cm. and probably becoming confluent.

On bark of dead, fallen limbs, about 12 mm. in diameter, of a frondose species. Mexico. December.

P. exigua is distinguished among our species by its clustered, small, snow-white fructifications which crack into small polygonal masses.

Specimens examined:

Mexico: near Guernavaca, altitude 4500 m., *W. A. & E. L. Murrill, 377,* type, and *378* (in Mo. Bot. Gard. Herb., 54474, 54473, respectively).

8. **P. laxa** Burt, n. sp.

Type: in Mo. Bot. Gard. Herb.

Fructifications broadly effused, thin, waxy-membranaceous, loosely attached to the substratum by a cottony subiculum, tender, small pieces separable, becoming pale ivory-yellow in the herbarium, even, not much cracked, the margin thinning out, fibrillose, with some mycelial strands; in section 200–300 μ thick, not colored, with the thin, compact hymenium supported by a very broad layer of loosely interwoven, thin-walled, granule-incrusted hyphae 1½–2 μ, rarely 3 μ, in diameter, with the hyphae more densely arranged in a middle zone of this layer; no gloeocystidia; cystidia not incrusted or with only a few incrusting granules, 4½–6 μ in diameter, protruding up to about 30–50 μ beyond the basidia, often capitate and 6–9 μ in diameter at the apex; basidia up to 6 μ in diameter, with 4 sterigmata; spores hyaline, even, spherical, 4½–6 μ in diameter, copious.

Fructifications 2–6 cm. long, 1–2½ cm. wide.

In woods on bark with the wood underneath wholly decayed. British Columbia. December.

P. laxa is probably white when growing and assumed the pale ivory-yellow tint in the herbarium; the aspect is like that of *P. arachnoidea* but with globose spores. *P. sphaerospora* of Europe has similar spores but much coarser, erect hyphae and different cystidia.

Specimens examined:

British Columbia: Sidney, *J. Macoun, 8,* type (in Mo. Bot. Gard. Herb., 5767).

9. **P. humifaciens** Burt, n. sp.

Type: in Burt Herb.

Fructifications effused, circular, thin, membranaceous, loosely attached by white rhizomorphic strands from the substratum, easily separable, white, becoming somewhat pale pinkish buff in the herbarium, the margin thinning out, floccose; in section 150 μ thick, not colored, with hyphae hyaline, up to 5 μ in diameter and coarsest next to the substratum, very loosely arranged, branching and becoming 3 μ in diameter towards the hymenial layer, nodose-septate, with few incrusting granules; no gloeocystidia, hymenial layer 30–40 μ thick, continuous; cystidia not incrusted, 3–3½ μ in diameter at base, protruding 25–40 μ,

tapering, attenuated to a long and very sharp point; basidia with 4 sterigmata; spores hyaline, even, subglobose, about 2½ × 2 μ, copious.

Fructifications 2–2½ cm. in diameter.

On very rotten coniferous log—perhaps *Thuja*. Washington. October. Rare.

P. humifaciens was so sparingly and loosely connected with the substratum by the white, mycelial strands that the impact of a hatchet against the log caused fructifications to fall away. *P. arachnoidea*, a related species, has quite different hyphae and cystidia and mode of attachment.

Specimens examined:

Washington: Chehalis, *C. J. Humphrey, 6266*, type.

10. P. candida (Pers.) Lyman, Boston Soc. Nat. Hist. Proc. **33**: 167. *pl. 20, f. 44–55, pl. 26, f. 138.* F. 1907.

Aegerita candida Persoon, Roemer Neues Mag. Bot. **1**: 120. 1794 (imperfect stage); Syn. Fung. 684. 1801; Fries, Syst. Myc. **3**: 220. 1829; Sacc. Syll. Fung. **4**: 661. 1886.—*Sclerotium Aegerita* Hoffmann, Fl. Germ. **2**: *pl. 9, f. 1.* 1795.—*Peniophora Aegerita* (Hoffm.) v. Höhnel & Litschauer, K. Akad. Wiss. Wien Sitzungsber. **116**: 814. 1907; **123**: 83. 1914; Sacc. Syll. Fung. **21**: 410. 1912; Bourdot & Galzin, Soc. Myc. Fr. Bul. **28**: 382. 1913; Rea, Brit. Basid. 687. 1922.—*Kneiffia farinosa* Bresadola, Ann. Myc. **1**: 105. 1903; Sacc. Syll. Fung. **17**: 178. 1905.

Illustrations: See Sacc. Syll. Fung. **19**: 25, for numerous figures of imperfect stage.

Fructifications effused, thin, adnate, very tender, at first farinose, then forming a continuous hymenium, white to pale cream-color, very minutely velvety under a lens, the margin thinning out, indeterminate, usually with clusters of the minute, globose, white, imperfect stage adjoining; in section 40–100 μ thick, not colored, with hyphae suberect, thin-walled, collapsing, of irregular outline, about 4 μ in diameter; no gloeocystidia; cystidia incrusted, scattered, starting from the substratum, 40–100 × 6–12 μ; spores hyaline, even, subglobose, 6–7 × 4½–6 μ.

Fructifications 2–4 cm. long, 1–2 cm. wide.

On decaying wood and fallen branches of *Alnus*, *Populus*, *Acer*,

Ulmus, etc., and on the ground. In Europe, and from Massachusetts to Missouri. October and November. Rare.

The association of the effused, white fructifications of *P. candida*, with the clustered, small, globose, white or cream-colored fructifications—about 5 or 6 to a mm.—of the imperfect stage, *Aegerita candida*, affords an easy means of recognizing *P. candida*.

Specimens examined:

Poland: *Eichler*, part of the type of *Kneiffia farinosa*, comm. by Bresadola.

France: Allier, *H. Bourdot, 19908.*

New Hampshire: Hanover, *G. R. Lyman.*

Massachusetts: Arlington, *A. P. D. Piguet*, comm. by W. G. Farlow, 33; Waverly, *G. R. Lyman*, two gatherings.

New York: Ithaca Flats, *G. F. Atkinson.*

Missouri: Creve Coeur, *E. A. Burt* (in Mo. Bot. Gard. Herb., 56059), and *F. P. McWhorter* (in Mo. Bot. Gard. Herb., 57309).

11. P. cana Burt, n. sp.

Type: in Mo. Bot. Gard. Herb. and N. Y. Bot. Gard. Herb.

Fructifications effused, closely adnate, very thin, hypochnoid, not forming an interwoven membrane, pilose under a lens, the margin pruinose, indeterminate; in section 10–30 μ thick, not colored, consisting of short, erect, simple or once- or twice-branched hyphae 3–3½ μ in diameter, not incrusted, not nodose-septate, and of large cystidia; no gloeocystidia; cystidia heavily incrusted, conical, 50–60 × 10–18 μ, protruding 30–45 μ, starting from the substratum, very numerous; spores hyaline, even, 3–3½ × 1½ μ as seen on basidia.

Fructifications fragmentary, with the fragments 1½–2 cm. long, 10–15 mm. wide.

On dark, brittle wood humus—probably of a frondose species. Florida. March.

P. cana is so thin and hoary that it is likely to be regarded as a Hyphomycete unless examined with the microscope. The large, conical, incrusted cystidia and small spores distinguish it from *P. albugo.*

Specimens examined:

Florida: Cutler Hummock, *W. A. Murrill, 82*, type, and *83*,

comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 62102, 62103).

12. **P. irregularis** Burt, n. sp.

Type: in Mo. Bot. Gard. Herb.

Fructifications effused, very thin, adnate, flocculent, tender, white, interrupted, somewhat lacunose, not shining, the margin thinning out, with hyphae interwoven; in section 45–75 μ thick, not colored, composed of interwoven, hyaline, incrusted hyphae 2½ μ in diameter; no gloeocystidia; cystidia incrusted with coarse granules, 15–22 × 8–12 μ, barely protruding, confined to the hymenium; spores hyaline, even, 4½ × 2½ μ, borne 4 to a basidium.

Fructification 3½ cm. long and broken off at one end, 1 cm. wide.

On bark of a rotten frondose limb about 7 mm. in diameter. Cuba. December.

P. irregularis is a thin, white species of flocculent texture rather than waxy, with the dark substratum visible in small spaces not covered by the fructification.

Specimens examined:

Cuba: near Havana, *C. J. Humphrey, 2953*, type (in Mo. Bot. Gard. Herb., 9010).

13. **P. albofarcta** Burt, n. sp.

Type: in N. Y. Bot. Gard. Herb., Mo. Bot. Gard. Herb., and Burt Herb.

Fructifications effused, adnate, dry, spongy-membranaceous, light buff to pinkish buff in the herbarium, minutely velutinous under a lens, even, but little cracked, the margin thinning out, minutely tomentose; in structure 200–350 μ thick, not colored, composed of a broad layer of loosely interwoven, rather rigid hyphae 3–3½ μ in diameter, not incrusted, not nodose-septate, and of a dense hymenial layer about 100 μ thick; no gloeocystidia; cystidia incrusted, slender-fusiform, 50–90 × 6–9 μ, protruding up to 30 μ, numerous in all parts of the hymenial layer; spores hyaline, even, spherical, 3–4 μ in diameter, only few found but seem to belong.

Fructifications in fragments 5 mm.–2 cm. long, 5–10 mm. wide.

On very rotten wood of stump of orange tree (*Citrus*). Louisiana. December.

The fructifications of *P. albofarcta* are scarcely distinguishable in color from the rotten wood upon which grown. The occurrence on *Citrus* wood, velvety hymenium, globose spores, and thick and loosely interwoven subiculum seem good, distinctive characters.

Specimens examined:

Louisiana: Point à la Hache, *A. B. Langlois, 894*, type (in N. Y. Bot. Gard. Herb., Mo. Bot. Gard. Herb., 63729, and Burt Herb.).

14. **P. longispora** (Pat.) v. Höhnel, Ann. Myc. **3**: 325. 1905; Bourdot & Galzin, Soc. Myc. Fr. Bul. **28**: 392. 1913; Rea, Brit. Basid. 690. 1922.

Hypochnus longisporus Patouillard, Jour. de Bot. **1894**: 221. 1894; Sacc. Syll. Fung. **11**: 130. 1895.—*Kneiffia longispora* (Pat.) Bresadola, Ann. Myc. **1**: 105. 1903.

Fructifications widely effused, thin, pubescent, hypochnoid, not separable, white, becoming pale smoke-gray to pale olive-buff in the herbarium, the margin thinning out; in structure 30–120 μ thick, not colored, composed of suberect, loosely arranged, thin-walled, rough-walled, nodose-septate hyphae 2½–3 μ in diameter, and of cystidia; no gloeocystidia; cystidia acicular, rough-walled, 40–80 × 3–4 μ, protruding up to 60 μ; spores white in spore collection, even, 6–15 × 2½–3 μ.

Fructifications 3–10 cm. long, 1–5 cm. wide.

On bark and decaying wood of frondose species usually—especially *Populus*—rarely on conifers. In Europe and Africa and from Maine to Louisiana, Montana to Washington, and in the West Indies. July to March. Frequent.

P. longispora is well marked by its thin, white fructifications, hyphae, and needle-shaped cystidia rough or somewhat barbed with minute crystals, and the slender spores. There are few resupinate species which may be more confidently recognized.

Specimens examined:

Sweden: Lappland, *L. Romell, 316;* Stockholm, *L. Romell, 411.*

Poland: Russian Poland, *Eichler*, comm. by G. Bresadola.

Austria: Innsbruck, Tirol, *V. Litschauer.*

France: Allier, *H. Bourdot, 4073, 20807;* Aveyron, *A. Galzin, 11842, 17636,* comm. by H. Bourdot, 20861, 20862.

England: Doncaster, *E. M. Wakefield* (in Mo. Bot. Gard. Herb., 57118).

Maine: Kittery Point, *R. Thaxter & E. A. Burt.*

New York: East Berne, *C. H. Peck* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 14859).

Florida: Royal Palm Hummock, *W. A. Murrill, 105,* comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 62105).

Louisiana: Baton Rouge, *C. J. Humphrey, 2529* (in Mo. Bot. Gard. Herb., 20690); St. Martinville, *A. B. Langlois, br, dk.*

Montana: Columbia Falls, *C. J. Humphrey, 7239* (in Mo. Bot. Gard. Herb., 12526).

Idaho: Coolin, *J. R. Weir, 11255, 11541* (in Mo. Bot. Gard. Herb., 63259, 63296).

Washington: Olympia, *C. J. Humphrey, 6339.*

Cuba: *C. G. Lloyd, 436* (in Mo. Bot. Gard. Herb., 55169).

Jamaica: Blue Hole, *W. A. Murrill, 231,* comm. by N. Y. Bot. Gard. Herb.

Grenada: Grand Etang, *R. Thaxter,* comm. by *W. G. Farlow, 5.*

15. P. asperipilata Burt, n. sp.

Type: in Burt Herb. and U. S. Dept. Agr. Herb.

Fructifications effused, very thin, closely adnate, snow-white, velvety, the margin thinning out; in section 45–60 μ thick, not colored, composed of somewhat erect, loosely interwoven, thin-walled hyphae 3 μ in diameter, not incrusted, occasionally nodose-septate, which terminate in cystidia and clusters of basidia forming a hymenium barely continuous; no gloeocystidia; cystidia hair-like, slender, tapering to a sharp point, conspicuously denticulate or rough, 30–60 × 3–5 μ, protruding up to 50 μ beyond the basidia, very numerous; basidia 4-spored; spores hyaline, even, subglobose, 3½–4 μ in diameter.

Fructifications 1–2½ cm. in diameter in the fragmentary specimens known to me.

On rough bark of a frondose species. Louisiana and Texas. April and May. Rare.

P. asperipilata is a delicate, white, hypochnoid species covering very rough decaying bark. It is noteworthy by the abundant, needle-shaped, thin-walled cystidia with denticulate sides and by the globose spores.

Specimens examined:

Louisiana: St. Martinville, *A. B. Langlois, 44,* comm. by Lloyd Herb., 2395, and *1225,* comm. by W. G. Farlow (in Mo. Bot. Gard. Herb., 44067).

Texas: Houston, *H. W. Ravenel, 265,* type (in U. S. Dept. Agr. Herb. and Burt Herb.).

16. P. albugo Burt, n. sp.

Type: in Burt Herb.

Fructifications longitudinally effused, filmy-pruinose, adnate, whitish, pale smoke-gray in the herbarium, even, the margin indeterminate, pruinose; in section 25–50 μ thick, not colored, with the basidia and cystidia starting directly from the substratum or with only very short, erect, intervening hyphae 2½–3 μ in diameter, thin-walled, collapsing; no gloeocystidia; cystidia not incrusted, 40–50 × 4½–6 μ, protruding up to 40 μ; spores white in spore collections, even, 5–8 × 3–4½ μ, borne 4 to a basidium.

Fructifications 5–8 cm. long, 1½–3 cm. wide.

Under side of decaying frondose wood. Louisiana. December and April.

P. albugo is a whitish, pruinose, filmy growth resembling in aspect the young sterile mycelia which are sent in for determination in nearly all extensive series of specimens, but in this instance Mr. Langlois took spore falls on glass from the specimens—a highly commendable method of saving time, which is wasted when sectional preparations are made of mere mycelia, and also of keeping rubbish from preservation in the herbarium. *P. albugo* is related to *P. detritica* of France but has less membranaceous fructifications and more elongated spores.

Specimens examined:

Louisiana: St. Martinville, *A. B. Langlois, ba,* type, and *dl.*

17. P. albula Atkinson & Burt, n. sp.

Type: in Burt Herb.

Fructifications long-effused, adnate, thin, tender, small pieces separable, white, becoming light buff when old and in the herbarium, somewhat granular, becoming cracked into polygonal masses 1–2 mm. in diameter, the margin thinning out; in section 70–200 μ thick, not colored, composed of suberect, thin-walled, branching hyphae about 3 μ in diameter, occasionally nodose-septate, not incrusted, sometimes slightly brownish near the substratum; no gloeocystidia; cystidia not incrusted, 3 μ in diameter, tapering towards the apex, protruding 10–20 μ, sometimes very few and inconspicuous; spores hyaline, even, 4–6 × 2½–3 μ.

Fructifications 2–20 cm. long, 1–2 cm. wide.

On bark of fallen decaying branches on the ground, of *Alnus*, *Acer*, *Tilia*, *Populus*, and other frondose species. Canada to Alabama and westward to Washington. July to February. Frequent.

P. albula belongs near *P. Sambuci* on account of its white color, somewhat granular hymenium, and minute cystidia which are not incrusted and sometimes so few and inconspicuous that they may possibly be overlooked, and the specimen referred to *Corticium*. *P. albula* differs from *P. Sambuci* in not having the hyphae incrusted in a subhymenial zone and in having them sometimes slightly brownish towards the substratum.

Specimens examined:

Exsiccati: Ellis, N. Am. Fungi, 409, under the name *Corticium calceum.*

Canada: *J. Macoun, 5,* type; Beechwood Cemetery, other locality not given, *J. Macoun, 58;* Ottawa, *J. Macoun, 9.*

Maine: Kittery Point, *R. Thaxter & E. A. Burt.*

New Hampshire: Chocorua, *W. G. Farlow, D* (in Mo. Bot. Gard. Herb., 56132).

Massachusetts: Sharon, *A. P. D. Piguet, 137,* comm. by Farlow Herb. (in Mo. Bot. Gard. Herb., 59628); Wayland, *A. B. Seymour, T 8* (in Mo. Bot. Gard. Herb., 19550).

New York: Albany, *H. D. House,* 3 gatherings (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 57447, 59683, 59686); Ithaca, several collections by *G. F. Atkinson, H. L. Jackson, C. O. Smith,* and *Van Hook,* comm. by G. F. Atkinson, 8028,

8069, 8072, 8235, 14392, 14393; Karner, *H. D. House* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 54373); New York, Bronx Park, *L. M. Underwood* (in N. Y. Bot. Gard. Herb., Mo. Bot. Gard. Herb., 61592, and Burt Herb.).

New Jersey: Newfield, *J. B. Ellis, J 87, D 81*, comm. by Farlow Herb. (in Mo. Bot. Gard. Herb., 8266, 14689, 7458), and in Ellis, N. Am. Fungi, 409.

Pennsylvania: Philadelphia, *A. S. Rhoads*, comm. by L. O. Overholts, 2679 (in Mo. Bot. Gard. Herb., 5919).

Maryland: Takoma Park, *C. L. Shear, 1271, 1272.*

District of Columbia: Chive Chose, *J. R. Weir, 372* (in Mo. Bot. Gard. Herb., 17649).

Virginia: Chain Bridge, *A. S. Rhoades*, comm. by L. O. Overholts, 3969 (in Mo. Bot. Gard. Herb., 54986).

Florida: *W. W. Calkins*, comm. by U. S. Dept. Agr. Herb.

Alabama: Montgomery, *R. P. Burke, 127, 157* (in Mo. Bot. Gard. Herb., 5499, 44964).

Iowa: Woodbine, *C. J. Humphrey & C. W. Edgerton*, comm. by C. J. Humphrey, 6511, 6546 (in Mo. Bot. Gard. Herb., 11063, 11276).

Washington: Bingen, *W. N. Suksdorf, 894, 900.*

18. **P. Sambuci** (Pers.) Burt, n. comb.

Corticium Sambuci Persoon, Roemer Neues Mag. Bot. **1**: 111. 1794; Fries, Epicr. 565. 1838; Hym. Eur. 660. 1874; Berkeley, Outlines Brit. Fung. 276. 1860; Massee, Linn. Soc. Bot. Jour. **27**: 137. 1890; Wakefield, Brit. Myc. Soc. Trans. **4**: 115. *pl. 3, f. 1, 2.* 1913; Rea, Brit. Basid. 677. 1922.—*Thelephora Sambuci* Persoon, Syn. Fung. 581. 1801; Myc. Eur. **1**: 152. 1822 (in subgenus *Corticium*).—*Hypochnus Sambuci* (Pers.) Sacc. Syll. Fung. **6**: 656. 1888.—*Thelephora sera* Persoon, Syn. Fung. 580. 1801; Myc. Eur. **1**: 151. 1822 (in subgenus *Corticium*).—*Corticium serum* (Pers.) Bresadola, I. R. Accad. Agiati Atti III. **3**: 112. 1897; Bourdot & Galzin, Soc. Myc. Fr. Bul. **27**: 246. 1911.

Fructifications effused, closely adnate, incrusting, not separable, snow-white or chalk-white, sometimes becoming pale cream-color in the herbarium, granular and pruinose, the margin thinning out; in section 100–250 μ thick, not colored, composed

of suberect, somewhat interwoven, thin-walled, incrusted hyphae $2\frac{1}{2}$–3 μ thick, occasionally nodose-septate; no gloeocystidia; cystidia not incrusted, tapering towards the apex, 3 μ in diameter, protruding 10–30 μ beyond the basidia; spores hyaline, even, 4–$5\frac{1}{2} \times 3$–4 μ.

Fructifications 3–10 cm. long, 1–3 cm. wide, often surrounding small twigs.

On bark and wood of fallen *Sambucus* and other frondose species. In Europe and throughout North America. Throughout the year. Very common.

This species is very common, and has become so well known to mycologists early in their work, under its original name *Corticium Sambuci* that there has been a reluctance, which I feel also, to call it *Peniophora Sambuci*, which its structure really requires. Its cystidia have been termed sterile basidia and cystidioles, but they differ in no morphological respect from the cystidia of other species of *Peniophora*. The species occurs in especially fine condition on *Sambucus*, and it is well to use such specimens as standards for comparison.

Specimens examined:

Exsiccati: Bartholomew, Fungi Col., 3135, 4715; Brinkmann, Westfälische Pilze, 10; Cavara, Fungi Longobardiae, 63, 213; Cooke, Fungi Brit., 408; Ell. & Ev., Fungi Col., 607, under the name *Corticium scutellare;* Krieger, Fungi Sax., 523; Romell, Fungi Scand., 35; Roumeguere, Fungi Gallici, 2911; Westendorp, Herb. Crypt. Belge, 588.

Sweden: Stockholm, *L. Romell, 129, 200,* and in Romell, Fungi Scand., 35.

Germany: Saxony, *Krieger,* Fungi Sax., 523; Westphalia, in Brinkmann, Westfälische Pilze, 10.

Austria: Tirol, Innsbruck, *V. Litschauer.*

Italy: Rome, *G. Bresadola;* Brixia, *A. Marozzi,* and Papia, *F. Cavara,* in Cavara, Fungi Longobardiae, 63 and 213 respectively.

England: Forden, *E. Vize,* in Cooke, Fungi Brit., 408.

Belgium: Courtrai, in Westendorp, Herb. Crypt. Belge, 588.

France: *Fautrey,* comm. by Lloyd Herb., 4326, 4357; Bois de Vincennes, *N. Patouillard* (in N. Y. Bot. Gard. Herb., and

Mo. Bot. Gard. Herb., 55906); Rouen, in Roumeguere, Fungi Gallici, 2911.

Canada: *J. Macoun, 21, 26;* Lake Rosseau, *E. T. & S. A. Harper, 754;* Ottawa, *J. Macoun, 370.*

Maine: *F. L. Harvey* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 55804).

New Hampshire: Chocorua, *W. G. Farlow, 2,* and *C3* (in Mo. Bot. Gard. Herb., 43893).

Vermont: Grand View Mountain, *E. A. Burt;* Middlebury, *E. A. Burt,* 4 gatherings; Weybridge, *E. A. Burt.*

Massachusetts: East Wareham, *C. L. Shear, 2903* (in Mo. Bot. Gard. Herb., 15448).

New York: Clarksville, *C. H. Peck,* comm. by N. Y. State Mus. Herb. (in Mo. Bot. Gard. Herb., 18281); Constableville, *C. H. Peck,* comm. by N. Y. State Mus. Herb., T4 (in Mo. Bot. Gard. Herb., 54571); Ithaca, *G. F. Atkinson, 942, 4567, 8047, 22960;* Lyndonville, *C. E. Fairman,* comm. by N. Y. State Mus. Herb. (in Mo. Bot. Gard. Herb., 57512); Marcellus, *L. M. Underwood, 62* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61595); New York, *W. A. Murrill* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61595).

New Jersey: Newfield, *J. B. Ellis,* in Ell. & Ev., Fungi Col., 607.

Pennsylvania: Trexlertown, *W. Herbst, 11.*

Louisiana: Baton Rouge, *Edgerton & Humphrey,* comm. by C. J. Humphrey, 5662; St. Martinville, *A. B. Langlois, dd, 37,* comm. by Lloyd Herb., 2384, and *1944,* comm. by W. G. Farlow (in Mo. Bot. Gard. Herb., 44065).

Michigan: Ann Arbor, *C. H. Kauffman* (in Mo. Bot. Gard. Herb., 5584); Gogebic County, *E. A. Bessey, 372* (in Mo. Bot. Gard. Herb., 56636).

Missouri: Creve Coeur, *L. O. Overholts* (in Mo. Bot. Gard. Herb., 63704); St. Louis, *E. A. Burt* (in Mo. Bot. Gard. Herb., 63466, 58335).

Kansas: Stockton, *E. Bartholomew, 5815, 8206* (in Mo. Bot. Gard. Herb., 16709, 62175), and in Bartholomew, Fungi Col., 4715; Rooks County, *E. Bartholomew, 2045* (in Mo. Bot. Gard. Herb., 4827).

Washington: Bainbridge Island, *E. Bartholomew,* in Bartholo-

mew, Fungi Col., 3135; Olympia, *C. J. Humphrey, 6311;* Sedro-Woolley, *C. J. Humphrey, 7464.*

California: Claremont, *I. M. Johnston,* comm. by L. O. Overholts, 3645 (in Mo. Bot. Gard. Herb., 54699); Santa Catalina Island, *L. W. Nuttall, 522b* (in Mo. Bot. Gard. Herb., 57622).

Mexico: Guernavaca, *W. A. & E. L. Murrill, 391,* comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 54548); Orizaba, *W. A. & E. L. Murrill, 756,* comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 54644).

19. P. Thujae Burt, n. sp.

Type: in Burt Herb.

Fructifications effused, thin, closely adnate, white, sometimes becoming cartridge-buff in the herbarium, the margin thinning out; in section 40–150 μ thick, not colored, with the hyphae loosely arranged, suberect, interwoven, 2–3 μ in diameter, nodose-septate, thin-walled, becoming incrusted in a subhymenial zone; no gloeocystidia; cystidia hair-like, not incrusted, 3 μ in diameter at the base, tapering upward and sometimes somewhat capitate at apex, protruding 20–30 μ beyond the basidia; spores white in a spore collection, 4–5 × 3 μ.

Fructifications 2–6 cm. long, 1–2 cm. wide, on trunks of *Thuja,* more rarely on *Juniperus* and *Pinus Strobus.* Canada to Massachusetts, and westward to Missouri. July to October. Occasional.

P. Thujae may be recognized by its thin, white fructifications on white cedar, with microscopic structure as stated. It differs from *Peniophora Sambuci* in having thinner fructifications, not becoming granular and pruinose, cystidia numerous, and in occurrence on a coniferous substratum.

Specimens examined:

Canada: *J. Macoun 62;* St. Lawrence Valley, *J. Macoun, 68, 80;* Ottawa, *J. Macoun* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 55813), and *45,* and *J. M. Macoun* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 56078); Quebec, Hull, *J. Macoun, 173.*

Vermont: Middlebury, *E. A. Burt,* 3 gatherings, one of which is the type.

Massachusetts: Magnolia, *W. G. Farlow, f;* Newton, *W. G. Farlow.*

New York: Ithaca, *G. F. Atkinson, 14416;* North River, *C. H. Peck,* comm. by N. Y. State Mus. Herb., T5 (in Mo. Bot. Gard. Herb., 54569).

Missouri: St. Louis, *E. A. Burt.*

20. P. montana Burt, n. sp.

Type: in Burt Herb.

Fructifications effused, thin, adnate, tender, whitish to ivory-yellow, widely cracked in drying and showing the loose subiculum on the sides of the crevices, the margin thinning out, somewhat floccose; in section 200–225 μ thick, not colored, composed of loosely interwoven, thin-walled, hyaline hyphae 4–5 μ in diameter, not incrusted, not nodose-septate, of irregular outline; no gloeocystidia; cystidia hair-like, not incrusted, conical, tapering to a sharp apex, 6–9 μ in diameter at the base, protruding up to 40 μ; spores hyaline, even, cylindric, slightly curved, 12–14 × 4–5 μ.

Fragmentary fructification 4 cm. long, 1 cm. wide.

On badly decayed coniferous wood at an altitude of 10,000 ft. Colorado. July. Rare.

P. montana is noteworthy by having spores as large as those of *P. mutata,* but the fructifications are thinner and more tender than those of *P. mutata* and occur on coniferous wood and have no gloeocystidia.

Specimens examined:

Colorado: Ouray, *C. L. Shear, 1188,* type.

21. P. terricola Burt, n. sp.

Type: in Burt Herb.

Fructifications effused, thin, closely adnate, somewhat membranaceous, white, not waxy, the margin indeterminate, thinning out; in section 100–200 μ thick, not colored, composed of suberect, branching hyphae 3–6 μ in diameter, incrusted, densely interwoven and with more or less sand intermixed; no gloeocystidia; cystidia not incrusted, cylindric, 4–6 μ in diameter, protruding 20–50 μ beyond the basidia; spores hyaline, even, 4–6 × 3–4 μ.

Fructifications received in fragments but probably about 1–3 cm. in diameter.

On ground in mixed woods. New York and Louisiana. April and June.

The fructifications of *P. terricola* contain so much of the sand from the earth substratum that it is difficult to secure sections or to distinguish the fructification proper from its vegetative mycelium. The occurrence in small white patches on the ground, and the characters of spores and cystidia may enable recognition of this species which is probably common.

Specimens examined:

New York: Ithaca, *G. F. Atkinson, 22658, 22659,* type.

Louisiana: St. Martinville, *A. B. Langlois, bq.*

22. **P. magnahypha** Burt, n. sp.

Type: in Mo. Bot. Gard. Herb. and Farlow Herb.

Fructifications interruptedly effused, thin, adnate, between pale drab-gray and pale vinaceous-fawn, contracting in drying into small, more or less completely separated masses, not waxy, the margin thinning out; in section 150–180 μ thick, not colored, composed of erect hyphae 9–10 μ in diameter which start from the substratum at points 30–100 μ apart, branch repeatedly into branches of smaller diameter, are sparingly granule-incrusted, and terminate in large clusters of basidia and one or a few cystidia forming a hymenium; no gloeocystidia; cystidia not incrusted, septate, 9 μ in diameter, protruding up to 60 μ beyond the basidia; basidia with 4 sterigmata; spores hyaline, even, 9–10 × 6 μ.

Fructifications up to 4 cm. long, 2 cm. wide.

On decaying wood of a frondose species. Florida. Autumn.

While preliminary inspection of *P. magnahypha* with a lens does not promise more than any one of the great number of little-differentiated, perplexing, whitish resupinate species difficult to identify yet doing an important work in splitting up complex organic compounds, nevertheless its structural characters are unique. The combination of coarse, scattered, trunk-like, erect hyphae with the main trunk hypha or some of its principal branches protruding through and beyond the flat-topped cluster

of basidia as a transversely septate cystidium should lead to the ready recognition of this species when sectional preparations are studied.

Specimens examined:

Florida: Cocoanut Grove, *R. Thaxter*, *57*, type (in Mo. Bot. Gard. Herb., 43947).

23. P. exilis Burt, n. sp.

Type: in Mo. Bot. Gard. Herb.

Fructifications longitudinally effused, very thin, closely adnate, pale olive-buff, even, somewhat velutinous, the margin thinning out, indeterminate; in section 30–60 μ thick, not colored, composed of erect, bushy-branched hyphae 3 μ in diameter, ascending from the substratum, soon terminating in basidia and cystidia, not nodose-septate, with very little, if any, incrustation; no gloeocystidia; cystidia hair-like, irregular, flexuous, 30 × 4½–5 μ, protruding up to 20 μ, few and scattered; basidia simple, with 4 short sterigmata; spores hyaline, even, 4½–5 × 2½–3 μ.

Fructifications 1–6 cm. long, about 1 cm. wide.

On bark of decaying branches of frondose species in moist virgin forest. Mexico. January.

The fructifications of *P. exilis* occur as a thin, downy, gray coating on very rotten branches 1–2 cm. in diameter. The pale olive-buff color should be helpful in separating this species from the great number more white in color.

Specimens examined:

Mexico: Guernavaca, *W. A. & E. L. Murrill*, *385*, comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 54467); Orizaba, *W. A. & E. L. Murrill*, *757*, type, and *780*, comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 54619, 54620).

24. P. livida Fries in herb. under *Corticium*, n. sp.

Peniophora serialis in part of v. Höhnel & Litschauer, Bourdot & Galzin, and Rea.—Not *Corticium seriale* Fries of Fries Herb.—Not *Xerocarpus Cacao* Karsten, Hedwigia **29**: 271. 1890.

Type: in Herb. Fries, determined by E. Fries as *Corticium lividum.*

Fructifications longitudinally effused, closely adnate, waxy-soft, variable in color, pale olive-gray and pale olive-buff to fawn-color in the herbarium, glabrous, even, not cracked usually, rarely with a few fissures from contraction in drying, the margin thinning out; in section 75–500 μ thick, not colored, composed of densely interwoven, rather erect hyphae about 3 μ in diameter, indistinct, with the wall gelatinously modified; no gloeocystidia; cystidia not incrusted, tapering to a sharp apex, 3½–6 μ in diameter, protruding up to 40 μ beyond the basidia; spores hyaline, even, 4–5 × 1½–2 μ.

Fructifications 3–12 cm. long, 1–3 cm. wide.

Generally on old, decaying, coniferous wood, rarely on frondose wood. Europe, Louisiana, and British Columbia. Throughout the year.

P. livida may be best recognized by its close resemblance in aspect to even specimens of common *Corticium lividum* Pers., from which the presence of cystidia separate it. *P. livida* is one of the 3 species which European mycologists, following Bresadola, have been inclined to regard as sufficiently meeting the original description of *Corticium seriale* that one could ignore the fact that the species concerned do not agree in structure with one another, nor with any of the specimens in Kew Herbarium or Fries Herbarium, determined by Elias Fries as *Corticium seriale.* With regard to the appliability of the original description of *Corticium seriale,* it emphasizes rimose and testaceous fructifications which are not characters of *P. livida.* It might solve the problem of *Corticium seriale* Fr. to search in Sweden for a true *Corticium* which is testaceous and rimose and could be compared with the specimen in Kew Herbarium determined by Fries —something more like *Corticium Cacao* Karst, which has the hymenium somewhat deteriorated in my specimen so that I cannot be quite positive as to its genus from this specimen alone but seems to me to be a true *Corticium.*

Specimens examined:

Sweden: *E. Fries,* type, the thinner and paler of the specimens in Herb. E. Fries, determined by E. Fries as *Corticium lividum; L. Romell, 108, 109;* Femsjö, *L. Romell, 410;* Stockholm, *L. Romell, 198, 326, 345, 362.*

Austria: Tirol, Innsbruck, V. Litschauer, 3 specimens under the name *P. serialis.*

Louisiana: Bogalusa, *C. J. Humphrey, 5547.*

British Columbia: Revelstoke, *C. W. Dodge, 1639* (in Mo. Bot. Gard. Herb., 58784); Sidney, *J. Macoun, 9* (in Mo. Bot. Gard. Herb., 5768); Victoria, *J. Macoun, 541* (in Mo. Bot. Gard. Herb., 63728).

25. **P. phyllophila** Massee, Linn. Soc. Bot. Jour. **25:** 150. 1889; Sacc. Syll. Fung. **9:** 238. 1891; Rea, Brit. Basid., 697. 1922.

Asterostromella epiphylla v. Höhnel & Litschauer, K. Akad. Wiss. Wien Sitzungsber. **116:** 773. *text f. 3.* 1907.

Type: type distribution in Ravenel, Fungi Am., 457, under the name *Corticium epiphyllum.*

Fructification broadly effused, thin, closely adnate, not at all separable, whitish, becoming olive-buff in the herbarium, the margin thinning out; in section 40–80 μ thick, not colored, composed of suberect, interwoven, branching, thin-walled hyphae 2 μ in diameter, not incrusted, not nodose-septate, bearing clusters of basidia and branching paraphyses; also present occasional, tapering cystidia not incrusted, 30–45 × 4–10 μ, usually immersed, occasionally protruding up to 32 μ beyond the basidia; paraphyses colorless, branching at the hymenial surface into an antler-shaped form with very slender prongs; spores published by v. Höhn. & Lits. as 10–22 × 1½–3 μ.

Fructifications up to 5 cm. in diameter.

On fallen frondose leaves in South Carolina and on fallen decaying frondose limbs in Florida and Central America.

P. phyllophila is apparently a tropical species occurring more frequently on epidermis of small fallen twigs and ranging northward to South Carolina. I have studied specimens of the type distribution in the copies of Ravenel, Fungi Americana, of Farlow Herbarium, Missouri Botanical Garden Herbarium, United States Department of Agriculture Herbarium, and Burt Herbarium, and find these specimens to be the same in structure and all showing the distinctive antler-shaped paraphyses emphasized by v. Höhnel & Litschauer, and also tapering, non-

incrusted cystidia which are presumably what Massee really saw. I see no reason for displacing the specific name given by Massee for the later combination proposed by v. Höhnel & Litschauer. The basidia are so young that I found none bearing sterigmata nor spores and only twice slender spores 12–15 × 3 μ.

Specimens examined:

Exsiccati: Ravenel, Fungi Am., 457, type distribution, under the name *Corticium epiphyllum.*

South Carolina: Aiken, *H. W. Ravenel,* in Ravenel, Fungi Am., 457.

Florida: *W. W. Calkins.*

Central America: Panama Chagres, *F. L. Stevens, 1300* (in Mo. Bot. Gard. Herb., 63521).

26. P. piliseta Burt, n. sp.

Type: in N. Y. Bot. Gard. Herb., Mo. Bot. Gard. Herb., and Burt Herb.

Fructifications longitudinally effused, thin, somewhat membranaceous, tender, small pieces separable when moistened, whitish cream-color in the herbarium, not cracked, not shining, the margin thinning out, with the hyphae interwoven; in section 100–120 μ thick, not colored, composed of ordinary, interwoven, thin-walled hyphae about 3 μ in diameter, not incrusted nor nodose-septate, and of a system of hyaline tissue about 1 μ in diameter, not taking stain, branching like the coarser tissue of *Corticium investiens* and with its delicate antler-shaped branches barely visible in the hymenial surface; no gloeocystidia; cystidia not incrusted, cylindric, obtuse, 4½–6 μ in diameter, protruding 30–45 μ, confined to the surface of the hymenium; spores hyaline, even, cylindric, biguttulate, 9–11 × 4–4½ μ, copious.

Fructification 7½ cm. long, broken off at one end, 10–15 mm. wide.

On a very rotten, small, frondose limb about 1 cm. in diameter. Porto Rico. June.

P. piliseta is noteworthy by having in addition to an ordinary hyphal system in its fructification an additional system, intermixed with the first, of delicate, branching organs not taking

stain, such as is more distinctly visible, because coarser, in *P. phyllophila*, *Hypochnus pallescens*, *Corticium investiens* and *Grandinia granulosa*, and whose peripheral branches are more or less visible in the surface of the hymenium as antler-shaped paraphyses. *P. mexicana* has coarser hyphae and more hypochnoid surface.

Specimens examined:

Porto Rico: Martin Piña, Rio Piedras, *J. R. Johnston, 971 a*, type (in N. Y. Bot. Gard. Herb., Mo. Bot. Gard. Herb., 63243, and Burt Herb.).

27. P. mexicana Burt, n. sp.

Type: in N. Y. Bot. Gard. Herb. and Mo. Bot. Gard. Herb.

Fructifications longitudinally effused, adnate, dry, hypochnoid, thin, cream color in the herbarium, even, velutinous under a lens, not cracked, the margin thinning out; in section 140 μ thick, not colored, composed of even-walled, rather rigid, loosely arranged, branching hyphae 5–7 μ in diameter, not incrusted, not nodose-septate, which ascend obliquely from the substratum and bear a dense hymenium containing numerous cystidia and branching, filiform paraphyses (or perhaps conidiophores); no gloeocystidia; cystidia minutely incrusted or rough, tapering, 60–100 × 5–9 μ, protruding 40–60 μ; spores (perhaps conidia) hyaline, even, 6–7½ × 4–5 μ, copious.

Fructifications 4 cm. long and broken off at both ends, 6 mm. wide.

In depressed places on very rotten frondose wood. Mexico. January.

The dry, cream color or buff fructifications of hypochnoid texture, very coarse hyphae, large cystidia, and branching paraphyses or conidiophores in the surface of the hymenium are characters which should make this species recognizable, although my inability to demonstrate basidia convinces me that the type is in a conidial stage somewhat comparable with that of *Corticium roseum*.

Specimens examined:

Mexico: Orizaba, Nuevo, altitude 3600 m., *W. A. & E. L. Murrill, 773*, type (in Mo. Bot. Gard. Herb., 54633).

28. P. ludoviciana Burt, n. sp.

Type: in Burt Herb., and Farlow Herb. probably.

Fructifications effused, adnate, very thin, buff-yellow, darkening to cinnamon-buff in the herbarium, hymenium subvelutinous, not waxy, not cracking, the margin thinning out, paler; in section 40–75 μ thick, not colored, composed of suberect, branching, granule-incrusted, hyaline hyphae 3–4 μ in diameter; no gloeocystidia; cystidia hyaline, not incrusted, protruding 18–25 μ beyond the basidia; spores hyaline, even, 4–5 × 2½–3½ μ, somewhat flattened on one side.

Fructifications 1–2½ cm. long, ½–1½ cm. broad, becoming confluent.

On rotting decorticated wood of frondose species. Louisiana and Michigan. August and April. Rare.

P. ludoviciana closely resembles in aspect *P. flammea* and, like the latter, is not separable from the substratum and gives no noteworthy color changes when the sections are treated with potassium hydrate solution. Prolonged search has failed to find any immersed cystidia. *P. sulphurina* has larger, cracked fructifications with shining hymenium and yellow subiculum.

Specimens examined:

Louisiana: St. Martinville, *A. B. Langlois, 1919*, type, comm. by W. G. Farlow.

Michigan: Vermilion, *A. H. W. Povah, 369* (in Mo. Bot. Gard. Herb., 13921).

29. P. fusca Burt, n. sp.

Type: in Mo. Bot. Gard. Herb.

Fructifications effused, closely adnate, very thin, drying ecru-drab to drab, velvety, even, the margin not determinate, thinning out; in structure 35–45 μ thick, not colored, composed of loosely arranged, suberect, hyaline hyphae more or less incrusted, 3½–4 μ in diameter under the incrustation, not nodose-septate; no gloeocystidia nor conducting organs; cystidia hair-like, not incrusted, 7–12 μ in diameter at the base, protruding 40–125 μ beyond the basidia; basidia with 4 sterigmata; spores copious, hyaline, even, 6–7 × 3½ μ.

Fructifications 2–6 cm. long, 1–2 cm. wide, becoming larger by confluence.

On very rotten, decorticated and probably frondose wood. Alabama. June to October. Only 2 gatherings known.

P. fusca is a thin species of mucedinous aspect, like *P. longispora* but well characterized by its drab color, large cystidia, and moderately large spores. *P. cinerea* is sometimes of the same color but is less mould-like when viewed with a lens and with quite different structure and microscopic characters.

Specimens examined:

Alabama: Montgomery County, *R. P. Burke, 508,* type, and *836* (in Mo. Bot. Gard. Herb., 57301 and 63125 respectively).

30. P. gilvidula Bresadola, Mycologia **17**: 70. 1925.

Type: in Weir Herb.

Fructifications broadly effused, closely adnate, waxy, pinkish buff in the herbarium, here and there somewhat cracked, pruinose, the margin thinning out; in section 150–250 μ thick, not colored, 2-layered, the layer next the substratum 75–150 μ thick, composed of densely arranged hyphae about 4–5 μ in diameter, not incrusted, which are longitudinally interwoven in the type, hymenial layer 75–100 μ thick, composed of densely arranged, erect, coarse tissue; no gloeocystidia; cystidia not incrusted, 6–8 μ in diameter, protruding 30–60 μ beyond the basidia, not numerous, confined to the hymenium; basidia with 4 sterigmata; spores white in the mass, even, 5–6 × 2½–3½ μ, copious.

Fructifications 8–15 cm. long, 3–5 cm. wide.

On wood of log of *Pinus ponderosa*. Montana. September.

P. gilvidula has no especially distinctive character. The occurrence on *Pinus ponderosa* wood, buff color, thick hymenial layer, coarse hyphae, and small spores constitute the group of distinguishing characters. I have included under *P. gilvidula* a specimen from the same place which has the layer next to the substratum composed of erect hyphae.

Specimens examined:

Montana: Evaro, *J. R. Weir, 23305,* type (in Weir Herb.) and *426* (in Mo. Bot. Gard. Herb.).

31. P. zonata Burt, n. sp.

Type: in Mo. Bot. Gard. Herb.

Fructifications widely effused, closely adnate, thick, layered or zonate within, avellaneous, pruinose, contracting in drying and cracking into more or less connected masses about 1 mm. in diameter, the margin thinning out; in section 700 μ thick, probably stratose but perhaps with merely a hymenium of several (4 in the type) layers or zones, not colored, composed of densely arranged hyphae about 2½–3 μ in diameter, with somewhat gelatinously modified and indistinct, not sharply defined as tramal, and hymenial layers; no gloeocystidia; cystidia not incrusted, 3 μ in diameter at the base, tapering to a sharp apex, protruding up to 30 μ, very numerous in the surface of the hymenium; spores hyaline, even, curved, 4½ × 2½ μ, copious.

Portion of fructification 7 cm. long, 4 cm. wide, broken off at one end and on sides.

On decayed coniferous wood. Oregon. March.

The cystidia are so small and so very numerous in the hymenial surface and the season when collected—March—so early in the year that it is possible that this species is a stratose *Corticium* just starting a new outer stratum on its fructification, but I do not recognize it as a *Corticium* at present known to me. No matter what the genus may prove to be, the thick, somewhat liver-colored fructifications of layered or stratose structure, and notably cracked, should always make this species easy to recognize.

Specimens examined:

Oregon: Corvallis, *S. M. Zeller*, *2252*, type (in Mo. Bot. Gard. Herb., 63030).

32. P. laminata Burt, n. sp.

Type: in Burt. Herb.

Fructifications broadly effused, thin, adnate, not separable, cream-buff to warm buff, pubescent, somewhat tubercular, at length cracking into small masses 2–3 to a mm., the margin thinning out, fibrillose; in section 75–140 μ, rarely 200 μ, thick, not colored, becoming stratose, 1–6 strata, each composed of a supporting layer of loosely arranged, erect, hyaline hyphae 3–3½ μ in diameter, thin-walled, collapsing, not incrusted, and of a compact hymenial layer; no gloeocystidia; cystidia not incrusted,

hair-like, cylindric, obtuse, 3–3½ μ in diameter, protruding up to 30 μ beyond the basidia; basidia 4-spored; spores hyaline, even, 4½ × 3–3½ μ, copious.

Fructifications 2–8 cm. in diameter.

On bark and wood of fallen decaying trunk of *Pinus Strobus*. Vermont. December. Rare.

P. laminata is so suggestive in color and general aspect of the very common *Corticium investiens* that it is possible *P. laminata* has been passed by as a thin, young specimen of *C. investiens*, but the structure of these two species is quite different. The color of *P. laminata* does not fade in the herbarium; my gathering of nearly thirty years ago still has the color originally noted.

Specimens examined:

Vermont: Middlebury, *E. A. Burt*, type.

33. **P. guttulifera** (Karst.) Sacc. Syll. Fung. **9**: 240. 1891; Bourdot & Galzin, Soc. Myc. Fr. Bul. **28**: 400. 1913.

Gloeocystidium guttuliferum Karsten, Finska Vet. Soc. Bidrag Natur och Folk **48**: 430. 1889.

Type: a portion in Burt Herb.

Fructifications broadly effused, closely adnate, thin, becoming light buff to pinkish buff and chamois-colored in the herbarium, more or less studded with minute, hard, globular masses of resinous color which are visible under a lens but dissolve and disappear in aqueous mounts, the margin indeterminate, thinning out; in section 50–160 μ thick, not colored, with the hyphae erect, branching, 3–5 μ in diameter, not incrusted; no gloeocystidia; cystidia heavily incrusted, often obtuse, 40–90 × 10–15 μ, protruding up to 60 μ; spores white in a spore collection, even, depressed on one side, 7–10 × 3–4½ μ.

Fructifications 2–5 cm. long, 1–2½ cm. wide.

On decaying wood of *Populus*, *Betula*, *Acer*, and undetermined frondose species. In Europe, and from Canada to Louisiana and westward to Oregon. May to January. Rare.

The type specimen of *P. guttulifera* differs from *P. pubera* in having no gloeocystidia whatever and in bearing on its surface minute, globular, shining masses of such aspect as occur on tips of the granules in *Odontia sudans*. Such masses are also borne

on specimens from France communicated by Bourdot, and they are stated to be borne on the cystidia—this in addition to the usual incrustation of these cystidia. Since the resinous-colored masses disappear in the liquids to which they are subjected in sectioning and making aqueous preparations for microscopic study, I am inclined to regard the presence of these masses as perhaps due to weather conditions prevalent when the specimens bearing them were collected—a helpful, confirmatory specific feature when present, but not a necessary morphological character of *P. guttulifera*. Hence I have included under *P. guttulifera*, specimens which have spores 7–10 × 3–4½ μ, lack gloeocystidia, and have the aspect of *P. pubera*.

Specimens examined:

Finland: Mustiala, *P. A. Karsten*, type of *Gloeocystidium guttuliferum*, under the label *Gloeocystis guttulifera*.

Sweden: Femsjö, *E. A. Burt;* Göteberg, *L. Romell, 295*.

France: Allier, St. Priest, *H. Bourdot, 6656, 8458*.

Canada: Ottawa, *J. Macoun, 130 a*.

Maine: Kittery Point, *R. Thaxter & E. A. Burt*, 2 gatherings.

New Hampshire: Shelburne, *W. G. Farlow, 3*.

Vermont: Middlebury, *E. A. Burt*.

New Jersey: Newfield, *J. B. Ellis* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61398).

Alabama: Montgomery County, *R. P. Burke, 212, 478* (in Mo. Bot. Gard. Herb., 57083, 57295).

Louisiana: *A. B. Langlois, 256*, comm. by U. S. Dept. Agr. Herb.

Ohio: Lancaster, *W. A. Kellerman, 168*, comm. by U. S. Dept. Agr. Herb.

British Columbia: Agassiz, *J. Macoun, 129*.

Oregon: Corvallis, *W. A. Murrill, 940*, comm. by N. Y. Bot. Gard. Herb., 55715.

34. **P. flavido-alba** Cooke, Grevillea **8**: 21. *pl. 125, f. 14*. 1879; Sacc. Syll. Fung. **6**: 644. 1888; Massee, Linn. Soc. Bot. Jour. **25**: 151. 1889.

Type: in Kew Herb.

Fructifications broadly effused, thin, closely adnate, cracking in drying, becoming cartridge-buff to pinkish buff in the her-

barium, setulose with the large cystidia, the margin indeterminate, thinning out; in section 75–250 μ thick, not colored, composed of densely interwoven, hyaline hyphae about 3 μ in diameter, not incrusted, and of very numerous large cystidia, many of which are often tilted in all directions; no gloeocystidia; cystidia heavily incrusted, cylindric-fusiform to conical, sharp-pointed, 60–120 × 12–18 μ, numerous in all regions to the substratum, protruding up to 50 μ beyond the basidia; spores hyaline, even, white in a spore collection, 4½–6 × 2½–3½ μ.

Fructifications 5–15 cm. or more long, 2–5 cm. wide.

On bark of decaying limbs of *Carya*, *Liguidambar*, *Myrica*, *Quercus*, *Salix*, *Vitis*, and other frondose species. South Carolina to Louisiana, West Virginia and Ohio to Arkansas, and in the West Indies. July to April. Common.

P. flavido-alba resembles in aspect *P. pubera* with which it was confused by v. Höhnel & Litschauer in their study of specimens distributed by Ravenel and by Ellis in their exsiccati, but differs sharply from *P. pubera* in absence of gloeocystidia and in having smaller spores. Its spores are smaller than those of *P. guttulifera;* it lacks layered structure, and the cystidia are much larger than in either *P. Ravenelii* or *P. Roumeguerii.* There may be observed in sectional preparations a curious tilting of many cystidia, some towards the right and some towards the left while most are erect and the tilting is at varying angles, being occasionally quite parallel with the substratum. Such tilting is unique among the species of *Peniophora* known to me and is best shown by the immersed cystidia in sections from the thicker fructifications. The type specimen in Kew Herbarium is on the same substratum, *Myrica,* as the specimens distributed in Ravenel, Fungi Am., 226, and impressed me as probably being from the same gathering.

Specimens examined:

Exsiccati: Bartholomew, Fungi Col., 4741; Ellis, N. Am. Fungi, 1209; Ell. & Ev., N. Am. Fungi, 3412; Ravenel, Fungi Am., 226.

South Carolina: *P. H. Rolfs, 1622, 1625.*

Georgia: Atlanta, *E. Bartholomew, 5677, 5689* (in Mo. Bot. Gard. Herb., 44253); Darien, *H. W. Ravenel, 2529,* type (in

Kew Herb.) and specimens in Ravenel, Fungi Am., 226, and Ellis, N. Am. Fungi, 1209.

Florida: *W. W. Calkins*, comm. by W. G. Farlow (in Mo. Bot. Gard. Herb., 44634), and *628*, comm. by W. G. Farlow (in Mo. Bot. Gard. Herb., 44641, 44254); New Smyrna, *C. G. Lloyd, 2128;* Tallahassee, *E. Bartholomew, 5722* (in Mo. Bot. Gard. Herb., 44256).

Alabama: Auburn, *F. S. Earle & C. F. Baker, 2217* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61344); Montgomery County, *R. P. Burke, 68, 147, 164, 169, 237, 444, 463, 465, 475, 667* (in Mo. Bot. Gard. Herb., 18395, 7552, 44963, 44959, 57105, 57271, 57284, 57286, 57293, 63089).

Louisiana: Abita Springs, *A. B. Langlois, 2684;* Baton Rouge, *Edgerton & Humphrey*, comm. by C. J. Humphrey, 5665; New Orleans, *E. Bartholomew*, in Bartholomew, Fungi Col., 4741, and *5765* (in Mo. Bot. Gard. Herb., 44265); *A. B. Langlois, 460* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61476); St. Martinville, *A. B. Langlois, 2680*, comm. by Lloyd Herb., 3529, and *1954, 2679, aq. bt, cm,* and *cn.*

West Virginia: Ellis Coll., 48 (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61395).

Ohio: Cincinnati, *C. G. Lloyd, 4515, 4526, 4806.*

Kentucky: Crittenden, *C. G. Lloyd, 3115;* Mammoth Cave, *C. G. Lloyd, 1602*, and in Ell. & Ev., N. Am. Fungi, 3412.

Arkansas: Bigflat, *W. H. Long, 19894* (in Mo. Bot. Gard. Herb., 6387).

Cuba: San Antonio de los Baños, Havana Province, *Earle & Murrill, 88*, comm. by N. Y. Bot. Gard. Herb.; Pinar del Rio Province, *Earle & Murrill, 241*, comm. by N. Y. Bot. Gard. Herb.; Santiago de las Vegas, *H. Hasselbring* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61468).

Porto Rico: Rio Piedras, *J. A. Stevenson, 3366, 5582, 6068* (in Mo. Bot. Gard. Herb., 7574, 6944, 54685).

Jamaica: Hall's Delight, *F. S. Earle, 134*, comm. by N. Y. Bot. Gard. Herb.

35. P. vernicosa Ellis & Everhart in herb., n. sp.

Type: in N. Y. Bot. Gard. Herb., Mo. Bot. Gard. Herb., and Burt Herb.

Fructifications long and broadly effused, very thin, closely adnate, pinkish buff in the herbarium, even, somewhat puberulent and setulose under a lens, not cracked, the margin thinning out, indeterminate; in section 30–45 μ thick, not colored, composed of densely interwoven, hyaline hyphae about 3 μ in diameter, indistinct; no gloeocystidia; cystidia incrusted, fusiform, 40–50 × 10–15 μ, protruding up to 50 μ beyond the basidia; spores hyaline, even, 4–5 × 3–3½ μ.

Fructifications 10–12 cm. long, 2–3 cm. wide.

On dead pieces of *Celtis*. Florida and Louisiana. August and March.

The 3 gatherings under the name *P. vernicosa* in Ellis Collection of New York Botanical Garden and duplicates of these communicated to me directly by Langlois seem to be thin forms of 3 species, 2 of which are well known. The type of *P. vernicosa* shows the location of the fructification by the pinkish buff color of the area covered, somewhat varnish-like effect produced, and cystidia visible under a lens. There is the bare possibility that *P. vernicosa* may be demonstrated to be the very early stage of *P. flavido-alba* but my knowledge of the latter does not at present warrant such a conclusion.

Specimens examined:

Florida: Cutler Hammock, *W. A. Murrill, 86*, comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 62082).

Louisiana: St. Martinville, *A. B. Langlois, 1965*, type (in N. Y. Bot. Gard. Herb., Mo. Bot. Gard. Herb., 63726, and Burt Herb.).

36. P. texana Burt, n. sp.

Type: in Mo. Bot. Gard. Herb.

Fructifications long and broadly effused, adnate, thin, even, not shining, drying between cream-buff and pinkish buff and cracking transversely, the margin indeterminate, thinning out; in section about 100 μ thick, not colored, with the hyphae indistinct, interwoven, 3–3½ μ in diameter, not incrusted; cystidia incrusted, conical, often tilted, not colored, 45–55 × 10–12 μ, protruding beyond the basidia up to 45 μ; no gloeocystidia nor conducting organs; spores copious, hyaline, even, 4½–6 × 3–4½ μ.

Fructifications up to 25 cm. long, 5 cm. broad.

On bark of *Juniperus sabinoides*. Texas. October. Only the type collection known.

Although occurring on bark of *Juniperus*, *P. texana* is not at all related to *P. laevigata* and seems rather to belong in the group of species of which *P. flavido-alba* is best known. The occurrence on *Juniperus*, the large expanse of the fructifications, and large cystidia and spores should afford recognition of *P. texana*.

Specimens examined:

Texas: Austin, *W. H. Long, 21070*, type (in Mo. Bot. Gard. Herb., 55134).

37. P. flammea Burt, n. sp.

Type: in Burt Herb. and N. Y. Bot. Gard. Herb.

Fructifications effused, adnate, very thin, olive-ocher to deep chrome, fading to clay color in the herbarium, hymenium often with some granules, the margin thinning out, paler; in section 50–90 μ thick, not colored and with no color changes by potassium hydrate solution, with hyphae 3 μ in diameter, interwoven next to the substratum but suberect, branching and granule-incrusted towards the hymenium; no gloeocystidia; wholly immersed cystidia incrusted, 15–60 × 5–10 μ, few and scattered; hair-like cystidia not incrusted, 3–5 μ in diameter at base, protruding 20–30 μ beyond the basidia, are scattered in the surface of the hymenium; spores hyaline, even, 3½–5 × 1½–2½ μ.

Fructifications 1–10 cm. long, 5 mm.–2½ cm. broad.

On rotting wood and bark of frondose species and on under side of rotting leaves of *Sabal*. Florida, Alabama, Texas, Cuba, and Bermuda. March to June. Probably rare.

P. flammea has the intense yellow color of *Corticium chrysocreas* and *Odontia Wrightii* but, unlike these species, its sections do not become vinaceous and then bleach when treated with potassium hydrate solution and the structural details of the sections are quite different also. *Peniophora sulphurina* is yellow and has small spores, but the fructification of *P. flammea* is as closely adnate to, and inseparable from, the substratum as that of *P. cinerea*.

Specimens examined:

Florida: Tarpon Springs, *W. A. Murrill, 216*, comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 62121).
Alabama: Montgomery, *R. P. Burke, 3, 158* (in Mo. Bot. Gard. Herb., 17431, 44962).
Texas: Austin, *W. H. Long, 524*.
Cuba: *C. G. Lloyd, 421* (in Mo. Bot. Gard. Herb., 55172); El Yunque Mt., Baracoa, *L. M. Underwood & F. S. Earle, 1215*, type, comm. by N. Y. Bot. Gard. Herb.
Bermuda: Paget Swamp, *H. H. Whetzel, Abe* (in Mo. Bot. Gard. Herb., 58905).

38. P. isabellina Burt, n. sp.

Type: in Burt Herb.

Fructifications longitudinally effused, very thin, closely adnate, not at all separable, between light pinkish cinnamon and avellaneous, not shining, becoming somewhat minutely cracked, the margin thinning out; in section 50–75 μ thick, not colored, composed of innumerable cystidia and densely arranged hyphae $2\frac{1}{2}$–3 μ in diameter, indistinct; no gloeocystidia; cystidia incrusted, 30 × 6 μ, protruding up to 12 μ, fusoid, usually starting from the substratum; spores 6 × 3 μ present but so few found that they may not belong.

Fructification 8 cm. long and broken off at both ends, 1 cm. broad.

On dead canes of blackberry (*Rubus*), and perhaps on other frondose wood. Virginia and Alabama. June to September.

P. isabellina is as closely adnate as *P. cinerea* and *P. versicolor*, from both of which it differs in not being colored in section. The occurrence of the type on blackberry stems may be helpful in recognizing this species, but several other species also occur on blackberry stems. The specimen from Alabama, referred to *P. isabellina*, is probably specifically distinct.

Specimens examined:
Virginia: Woodstock, *C. L. Shear, 1191*, type.
Alabama: Montgomery County, *R. P. Burke, 62* (in Mo. Bot. Gard. Herb., 18207).

39. P. coccineo-fulva (Schw.) Burt, n. comb.

Phlebia coccineo-fulva Schweinitz, Am. Phil. Soc. Trans. N. S.

4: 165. 1832; Sacc. Syll. Fung. **11**: 112. 1895.—*Corticium rhodellum* Peck, N. Y. State Mus. Rept. **42**: 122. 1889.—*Peniophora rhodella* (Peck) Sacc. Syll. Fung. **9**: 239. 1891.—*Peniophora Karstenii* Massee, Linn. Soc. Bot. Jour. **25**: 153. 1889. —*Corticium calotrichum* Karsten, Rev. Myc. **10**: 73. 1888; Soc. pro Fauna et Fl. Fenn. Meddel. **16**: 21. 1888; Icones Hym. Fenn. **3**: 7. *pl. 4, f. 71*. 1891; Sacc. Syll. Fung. **6**: 617. 1888; **9**: 232. 1891.—*Peniophora rhodochroa* Bresadola, Mycologia **17**: 70. 1925.—*Peniophora leprosa* Bourdot & Galzin, Soc. Myc. Fr. Bul. **28**: 394. 1913.

Type: in Schweinitz Herb. and Farlow Herb.

Fructifications effused, adnate, becoming russet to Natal brown in the herbarium, sometimes cracked, the margin paler; in section typically vinaceous russet but sometimes not colored, 150–400 μ thick, 2-layered, the layer next to substratum 100–300 μ thick, composed of loosely interwoven, thin-walled hyphae 4–8 μ in diameter, with many rough-walled or incrusted, the hymenial layer very dense, typically colored, bearing the cystidia; cystidia hyaline or slightly colored, incrusted, 40–80 × 10–14 μ, protruding up to 50 μ; spores hyaline, even, 4–5 × 2–2½ μ.

Fructifications 4–10 cm. long, 2 cm. broad.

On rotting wood and bark of *Juglans*, *Quercus*, and other frondose species, rarely on conifers. Canada to Alabama and westward to British Columbia and California, and in Mexico; occurs in Europe also. July to December. Frequent.

P. coccineo-fulva has been confused with *P. velutina*, from which it differs when best developed, in more intense color, the vinaceous subhymenial layer often showing this color on edges of cracks in the fructification, and in the incrusted hyphae. Paler specimens which are not otherwise distinguishable from *P. velutina* I have now referred to *P. coccineo-fulva* when they have the large, incrusted hyphae of the latter, for the European concept of *P. velutina*, as shown by specimens under this name in Kew Herbarium and communicated to me by Bourdot, Bresadola, Romell, and Litschauer, has the hyphae not incrusted, with the exception of additional specimens from Bresadola and Romell which they distinguished as different from *P. velutina* by labelling as "*Peni-*

ophora velutina Fr. f. *pallidior,*" and which I cite below as *P. coccineo-fulva.* These European specimens have exactly the same structure as the authentic specimen of *Corticium calotrichum* sent to me by Karsten, who noted the large rough hyphae in the description in Icones Hym. Fenn. **3**: 7, but the hyphae are really granule-incrusted.

Specimens examined:

Exsiccati: Ell. & Ev., N. Am. Fungi, 2019, under the name *Peniophora velutina;* Ell. & Ev., Fungi Col., 707, under the name *Peniophora velutina;* Rabenhorst, Fungi Eur., 3231, under the name *Corticium alneum,* the type distribution of *Peniophora Karstenii.*

Finland: Mustiala, *P. A. Karsten,* authentic specimen of *Corticium calotrichum,* and in Rabenhorst, Fungi Eur., 3231.

Sweden: Femsjö, *L. Romell, 421;* on *Fagus,* Hangnen, Femsjö, *E. A. Burt.*

Germany: *Brinkmann,* comm. by Bresadola as *Peniophora velutina* Fr. f. *pallidior.*

France: Aveyron, *A. Galzin, 26563,* comm. by H. Bourdot, 32878, authentic specimen of *Peniophora leprosa.*

Canada: Hull, Quebec, *J. Macoun, 197;* Lambeth, Ontario, *J. Dearness, D 172b* (in Mo. Bot. Gard. Herb., 5482); Granton, *J. Dearness, 966* (in Mo. Bot. Gard. Herb., 22582); Ottawa, *J. Macoun 197, 291,* and *J. M. Macoun, 230* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 55756, 55920, 56081 respectively).

New Brunswick: Campobello, *W. G. Farlow, 2* (in part).

Maine: Boarstone Mountain, Piscataquis County, *W. A. Murrill, 2404* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61354).

New Hampshire: Chocorua, *W. G. Farlow, 43* (in Mo. Bot. Gard. Herb., 43972); North Conway, *A. S. Rhoads, 10* (in Burt Herb., and Mo. Bot. Gard. Herb., 56979).

Vermont: Middlebury, *E. A. Burt,* 2 gatherings.

New York: Albany, *H. D. House* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 59703); Alcove, *C. L. Shear, 1309;* Floodwood, *C. H. Peck* (in N. Y. State Mus. Herb., Burt Herb., and Mo. Bot. Gard. Herb., 55986); Hudson Falls,

S. H. Burnham, 36 (in Mo. Bot. Gard. Herb., 54457); Ithaca Flats, *G. F. Atkinson, 3090;* Karner, *H. D. House* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 54368); Lyndonville, *C. E. Fairman*, type of *Corticium rhodellum* (in N. Y. State Mus. Herb.); Westport, *C. H. Peck* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 55968).

New Jersey: Belleplain, *C. L. Shear, 1242;* Newfield, *J. B. Ellis*, in Ell. & Ev., N. Am. Fungi, 2019, and Fungi Col., 707, and (in Burt Herb., N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 57337, 63455).

Maryland: Takoma Park, *C. L. Shear, 1335.*

Pennsylvania: Nazareth, *Schweinitz*, type of *Phlebia coccineo-fulva* (in Herb. Schweinitz and Farlow Herb.).

Alabama: Auburn, comm. by Alabama Biological Survey; Montgomery, *R. P. Burke, 72, 188, 635* (in Mo. Bot. Gard. Herb., 17582, 57068, 63072).

Ohio: Cincinnati, *C. G. Lloyd, 2808.*

Michigan: Ann Arbor, *C. H. Kauffman, 35* (in Mo. Bot. Gard. Herb., 20025); New Richmond, *C. H. Kauffman, 26* (in Mo. Bot. Gard. Herb., 16386); Vermilion, *A. H. W. Povah, 5* (in Mo. Bot. Gard. Herb., 9225).

Wisconsin: Lake Geneva, *E. T. & S. A. Harper, 834, 961;* Madison, *C. J. Humphrey & M. C. Jensen, 631* (in Mo. Bot. Gard. Herb., 10275).

Colorado: Pike's Peak, *G. G. Hedgcock*, comm. by C. J. Humphrey, 2554 (in Mo. Bot. Gard. Herb., 9782).

Idaho: Priest River, *J. R. Weir, 131* (in Mo. Bot. Gard. Herb., 15762), and *16809*, type of *Peniophora rhodochroa* (in Weir Herb. and Mo. Bot. Gard. Herb., 63690).

British Columbia: Kootenai Mts. near Salmo, *J. R. Weir, 535* (in Mo. Bot. Gard. Herb., 21995).

California: Big Wash Cañon, Santa Catalina Island, *L. W. Nuttall, 889*, comm. by Field Mus. Nat. Hist. Herb. (in Mo. Bot. Gard. Herb., 57650).

Arizona: Coronado Nat. Forest, *G. G. Hedgcock*, comm. by C. J. Humphrey, 2547 (in Mo. Bot. Gard. Herb., 9906).

Mexico: Jalapa, *W. A. & E. L. Murrill, 144*, comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 6962).

40. P. laevis (Fr.) Burt in R. Fries, R. Sci. Soc. Gothoburgens Actis IV. **3**: [36]. 1900; in Peck, N. Y. State Mus. Bul. **54**: 954. 1902; v. Höhnel & Litschauer, K. Akad. Wiss. Wien Sitzungsber. **115**: 1550. 1906; Bourdot & Galzin, Soc. Myc. Fr. Bul. **28**: 398. 1913; Rea, Brit. Basid. 692. 1922.

Thelephora laevis Fries, Elenchus Fung. **1**: 206. 1828. Not *T. laevis* Persoon.—*Corticium laeve* Fries, Epicr. 560. 1838; Hym. Eur. 649. 1874.—*Kneiffia laevis* (Fries) Bresadola, Ann. Myc. **1**: 99. 1903.

Type: authentic specimen in Kew Herb.

Fructifications effused, membranaceous, adnate, separable from the substratum when moistened, drying light pinkish cinnamon to buff-pink and ochraceous buff, the margin radiately fibrillose; in section not colored, 300–400 μ thick, with the hyphae 3–4½ μ in diameter, not colored, granule-incrusted, densely crowded together and running parallel with the substratum and then ascending obliquely into the hymenium; cystidia incrusted or not incrusted, 40–60 × 4½–9 μ, protruding up to 30 μ, confined to the hymenial layer; spores white in a spore collection, even, 4½–6 × 2½–3 μ.

Fructifications 2–10 cm. long, 2–4 cm. broad.

On bark of frondose species. Europe, New Brunswick to Texas and westward to Washington and Oregon, in Cuba and in Island of Guam and in Japan. July to October. Not common.

Peniophora laevis is one of the species which Karsten understood as *Corticium radiosum* and sent under this name to Fries, as shown by the specimens in Herb. Fries determined by Karsten, and preserved by Fries without comment. Bresadola collected the species occasionally and communicated to me duplicates under the herbarium name *Peniophora albo-gilvida.* The above specimens agree in aspect with the authentic specimen of *Corticium laeve* from Fries in Kew Herb. and also agree with it in the details of microscopic structure including incrusted hyphae, smaller than those of *Peniophora coccineo-fulva* and more compactly and more longitudinally arranged than those of *P. sanguinea. P. affinis* does not have its hyphae at all incrusted.

Specimens examined:

Sweden: authentic specimen (in Kew Herb.); on *Betula*, *L. Romell, 122;* Gottenburg, *L. Romell, 120;* Stockholm, *L. Romell, 358.*

Finland: *P. Karsten, 32* (in Fries Herb., under the name *Corticium radiosum*); Mustiala, *P. Karsten*, under the name *C. radiosum*, comm. by Bresadola, and also on *Alnus* under the name *Peniophora velutina.*

Russian Poland: *Eichler, 107*, comm. by Bresadola.

France: Allier, St. Priest, *H. Bourdot, 8981*, under the name *P. Eichleriana.*

Italy: Trient, Alps Mts., *Bresadola*, two specimens.

New Brunswick: Campobello, *W. G. Farlow, 2.*

New Hampshire: Chocorua, *W. G. Farlow, 12* (in Burt Herb.) and *C 35, C 38, 40* (in Mo. Bot. Gard. Herb., 43963, 43967, 43971).

Vermont: Middlebury, *E. A. Burt*, three gatherings.

Massachusetts: Magnolia, *W. G. Farlow;* Williamstown, *W. G. Farlow, 9.*

New York: East Galway, *E. A. Burt;* East Schaghticoke, *C. H. Peck* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 55758); East Schodack, *C. H. Peck, 12;* Hague, *C. H. Peck, 2;* Ithaca, *G. F. Atkinson, 4598;* North Greenbush, *H. D. House, 14.234* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 44733); Snyder, *C. H. Peck, 16.*

New Jersey: Newfield, *J. B. Ellis, 2020*, comm. by W. G. Farlow, 22 (in Mo. Bot. Gard. Herb., 7943).

Virginia: Crabbottom, *W. A. Murrill, 169, 259* (in N. Y. Bot. Gard. Herb., 61557, 61568).

Alabama: Montgomery County, *R. P. Burke, 129, 213, 813* (in Mo. Bot. Gard. Herb., 11034, 57085, 63115).

Texas: Gonzales, *C. L. Shear, 1231.*

Kentucky: Crittenden, *C. G. Lloyd, 10113* (in Mo. Bot. Gard. Herb., 58689).

Ohio?: locality not stated, *C. G. Lloyd, 4195.*

Michigan: New Richmond, *C. H. Kauffman, 47* (in Mo. Bot. Gard. Herb., 3259).

Wisconsin: Blue Mounds, *E. T. & S. A. Harper, 943;* Lake Geneva, *E. T. & S. A. Harper, 836;* Palmyra, *A. O. Stucki, 53.*

Missouri: Perryville, *R. A. Studhalter & L. O. Overholts, 2706* (in Mo. Bot. Gard. Herb., 44290).

Nebraska: Lincoln, *C. L. Shear, 540.*

Idaho: Priest River, *J. R. Weir, 608* (in Mo. Bot. Gard. Herb., 63196).

British Columbia: Sidney, *J. Macoun, 10* (in Mo. Bot. Gard. Herb., 5728).

Washington: Bingen, *W. N. Suksdorf, 764;* Arlington, *C. J. Humphrey, 7610.*

Oregon: Eugene, *C. J. Humphrey, 6061;* Tidewater, *S. M. Zeller, 1985* (in Mo. Bot. Gard. Herb., 58762).

Cuba: Ceballos, *C. J. Humphrey, 2805.*

Island of Guam: *Edwards,* comm. by J. R. Weir, 10765 (in Mo. Bot. Gard. Herb., 56238).

Japan: Mt. Mikuma, Prov. Awaji, *A. Yasuda, 62* (in Mo. Bot. Gard. Herb., 56138).

41. P. subiculosa Burt, n. sp.

Type: in Mo. Bot. Gard. Herb. and N. Y. Bot. Gard. Herb.

Fructifications effused, somewhat membranaceous, tender, small pieces separable when moist, with the hymenium drying cartridge-buff, pulverulent, here and there cracked and showing the whitish subiculum which is pale chamois-colored next to the substratum and connected with chamois-colored marginal mycelial strands or cords; in section 400–500 μ thick, not distinctly colored, with the hyphae loosely interwoven, hyaline, 4 μ in diameter, not nodose-septate, granule-incrusted in all regions with large crystalline granules; cystidia heavily incrusted, 20–60 × 9 μ, protruding up to 15 μ, confined to the hymenium; spores hyaline, even, 3–3½ × 2½ μ, borne 4 to a basidium.

Fructifications 2–3 cm. long, 1 cm. broad.

On humus of frondose wood. Mexico. December. Only one collection known.

P. subiculosa is related to *P. Burtii* but differs from it in having larger and incrusted cystidia and all hyphae heavily incrusted.

Specimens examined:

Mexico: Guernavaca, *W. A. & E. L. Murrill, 396,* type (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 54550).

42. **P. septocystidia** Burt, n. sp.

Type: in N. Y. Bot. Gard. Herb., Mo. Bot. Gard. Herb., and Burt Herb.

Fructifications effused, the small patches becoming more or less confluent, membranaceous, separable, between warm buff and cinnamon-buff in the herbarium, somewhat tubercular through conforming to the irregularities of the substratum, the margin byssoid, with some mycelial strands; in section 250–400 μ thick, not colored, 2-layered, the layer next to the substratum much the thicker, composed of very loosely interwoven, incrusted hyphae 4–5 μ in diameter under the incrustation, not nodose-septate, the hymenial layer dense, 35–45 μ thick; no gloeocystidia; cystidia incrusted with a few, large, somewhat colored granules, transversely septate, 5 μ in diameter under the incrustation, protruding 30–35 μ, scattered along surface of hymenium; spores hyaline, even, cylindric, curved, 5–7 × 2½–3 μ.

Fructifications 5 mm.–2½ cm. in diameter after confluence.

On decaying bark and humus. West Indies. January.

P. septocystidia is somewhat related to *P. sanguinea*, *P. Burtii*, and *P. subiculosa*, but is of different color, with very coarse hyphae and noteworthy cystidia.

Specimens examined:

Jamaica: Troy and Tyre, Cockpit Country, *W. A. Murrill & W. Harris, 860*, type (in Burt Herb., N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61490).

43. **P. canadensis** Burt, n. sp.

Type: in Burt Herb.

Fructification effused, adnate, dry, hypochnoid, small pieces separable when moistened, cream-color in the herbarium, even, tomentose under a lens, not shining, the margin thinning out, of finely interwoven hyphae; in section 300–350 μ thick, not colored, stratose, each of the two strata composed of loosely arranged, erect, branching, nodose-septate, somewhat incrusted hyphae 4–6 μ in diameter, which are slightly colored near the substratum and hyaline elsewhere, and of a more compact hymenial layer containing cystidia; no gloeocystidia; cystidia incrusted, cylin-

dric, 50–90 × 6–9 μ, protruding up to 45 μ, very numerous in the hymenium; basidiospores hyaline, even, 7–8 × 4–5 μ, copious, four to a basidium; other spherical spores 3½–4 μ in diameter are present in addition to immersed basidiospores in the buried hymenium.

Fructification 2½ cm. long, 2 cm. wide, broken off at both ends.

On wood of coniferous log and bark of *Fraxinus*. Canada and New York. September and October.

The type of *P. canadensis* somewhat resembles *P. pubera* in aspect but has texture more suggestive of *Coniophora byssoidea*. Such aspect, together with the coarse hyphae, large spores, and numerous large cystidia should fix the species. Unfortunately, the type consists of but a single piece of the dimensions stated, which was present in a packet of *Corticium bombycinum*. The New York gathering consists of a group of very small fructifications only one stratum thick.

Specimens examined:

Canada: locality not given, *J. Macoun, 60* (in part), type.

New York: Ithaca, *G. F. Atkinson*, Cornell Univ. Herb., 8282.

44. P. cremea Bresadola, Fungi Trid. **2**: 63. *pl. 173, f. 2.* 1898; Sacc. Syll. Fung. **16**: 195. 1902; Bourdot & Galzin, Soc. Myc. Fr. Bul. **28**: 396. 1913; Wakefield, Brit. Myc. Soc. Trans. **5**: 131. 1914; Rea, Brit. Basid. 691. 1922.

Kneiffia cremea Bresadola, Ann. Myc. **1**: 100. 1903.—An *Corticium Eichlerianum* Bresadola, Ann. Myc. **1**: 95. 1903?

Type: in Bresadola Herb. probably, authentic specimens in Burt Herb.

Fructifications broadly effused, membranaceous, separable, white or cream-color to ochraceous buff and darkening somewhat in the herbarium, sometimes cracking when dry and showing the white subiculum, the margin white and cobwebby; in section 100–300 μ, rarely 500 μ, thick, not colored, composed of a broad layer next to the substratum of thick-walled, hyaline, erect hyphae 4½–6 μ in diameter, branching at a wide angle, sometimes dichotomously, more or less granule-incrusted towards the hymenial layer; hymenial layer dense, bearing protruding cystidia even-walled or incrusted about the apex and containing also immersed,

incrusted cystidia when thickened; protruding cystidia cylindric or tapering towards the apex, 5–10 μ in diameter at the base, protruding up to 60 μ beyond the basidia; immersed cystidia 40–60 × 9–10 μ; no gloeocystidia; spores white in a spore collection, even, 5–8 × 2½–3½ μ.

Fructifications 4–15 cm. long, 2–4 cm. wide.

On bark-covered and decorticated branches of frondose species on the ground. In Europe, Canada to Louisiana, and westward to the Pacific States and in Japan and in Natal, Africa. May to January. Infrequent but widely distributed.

P. cremea is readily recognizable among the species of the northern United States and Canada by its thick, white or creamy fructifications which have small spores, lack gloeocystidia, and are 2-layered with the thick under layer composed of coarse, loosely arranged, erect hyphae branching at an angle of towards 60° and often dichotomously. These hyphae and their arrangement are distinctive. *P. mutata* has the same aspect and color but differs by much longer spores and the presence of gloeocystidia. *P. velutina* has its hyphae ascending obliquely to the hymenial layer.

Specimens examined:

Sweden: *L. Romell, 196;* Femsjö, *L. Romell, 218.*

Germany: Westphalia, Lengerich, *Brinkmann, 341,* determined and communicated by Bresadola.

Russian Poland: *Eichler,* determined and communicated by Bresadola.

Austria: Tirol, Gries, *V. Litschauer;* Innsbruck, *V. Litschauer;* Stiermark, *V. Litschauer.*

France: Aveyron, *M. Galzin, 13292,* comm. by H. Bourdot, 20856.

England: Doncaster, *E. M. Wakefield* (in Mo. Bot. Gard. Herb., 57126).

Canada: *J. Macoun, 24.*

New Hampshire: Chocorua, *E. A. Burt.*

Vermont: Bristol, *E. A. Burt,* two gatherings; Middlebury, *E. A. Burt,* two gatherings.

Massachusetts: Magnolia, *W. G. Farlow, a;* Sharon, *A. P. D. Piguet,* comm. by W. G. Farlow.

New York: East Galway, *E. A. Burt,* three gatherings; Bergen

Swamp, Genesee County, *H. D. House* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 57473).

New Jersey: Newfield, *J. B. Ellis, 68* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 63425).

District of Columbia: *W. A. Murrill, 1496* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 63453, 63465).

Alabama: Montgomery County, *R. P. Burke, 800* (in Mo. Bot. Gard. Herb., 63108).

Louisiana: St. Martinville, *A. B. Langlois, k, 1386, 1963, 2631* (in Burt Herb., N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 63456, 63503).

Michigan: Gogebic County, *E. A. Bessey, 321* (in Mo. Bot. Gard. Herb., 56543).

Montana: Rexford, *E. E. Hubert,* comm. by J. R. Weir (in Weir Herb., and Mo. Bot. Gard. Herb., 63246).

Idaho: Coolin, *J. R. Weir, 11499, 11575* (in Mo. Bot. Gard. Herb., 63261, 63303), and an unnumbered specimen (in Weir Herb., and Mo. Bot. Gard. Herb., 63247); Priest River, *J. R. Weir, 609* (in Mo. Bot. Gard. Herb., 63197).

Manitoba: Swan River, *G. R. Bisby, 1049* (in Mo. Bot. Gard. Herb., 59036); Winnipeg, *G. R. Bisby, 1117* (in Mo. Bot. Gard. Herb., 59040).

British Columbia: Sidney, *J. Macoun, 23, 28, 73, 82, 104, 834* (in Mo. Bot. Gard. Herb., 5757, 55335, 5758, 5759, 55337, 55334).

Washington: Bingen, *W. N. Suksdorf, 867;* Chehalis, *C. J. Humphrey, 6260;* Everson, *C. J. Humphrey, 7453;* Kalama, *C. J. Humphrey, 6205.*

Oregon: Corvallis, *S. M. Zeller, 1867* (in Mo. Bot. Gard. Herb., 56871); Eugene, *C. J. Humphrey, 6088.*

California: Palo Alto, *W. A. Murrill, 1173,* comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 55706); Santa Catalina Island, Grand Canyon, *L. W. Nuttall, 1060,* comm. by Field Mus. Herb. (in Mo. Bot. Gard. Herb., 58883).

Japan: Sendai, *A. Yasuda, 46* (in Mo. Bot. Gard. Herb., 56160); Mt. Mikuma, Prov. Awaji, *A. Yasuda, 53* (in Mo. Bot. Gard. Herb., 56161).

Africa: Natal, Durban, *P. A. van der Bijl, 612* (in Mo. Bot. Gard. Herb., 59377).

45. P. velutina (DC) Cooke, Grevillea **8**: 21. *pl. 125, f. 15.* 1879; Sacc. Syll. Fung. **6**: 644. 1888; Massee, Linn. Soc. Bot. Jour. **25**: 152. 1889; Bourdot & Galzin, Soc. Myc. Fr. Bul. **28**: 398. 1913; Rea, Brit. Basid. 692. 1922.

Thelephora velutina De Candolle, Fl. Fr. **6**: 33. 1815; Fries, Elenchus Fung. **1**: 203. 1828.—*Corticium velutinum* (DC) Fries, Epicr. 561. 1838; Hym. Eur. 650. 1874.—*Kneiffia velutina* (DC) Bresadola, Ann. Myc. **1**: 100. 1903.

Fructifications broadly effused, membranaceous, separable, becoming vinaceous buff to fawn color in the herbarium, minutely velvety, the margin whitish, often extended in branching mycelial strands; in section not colored, 250–500 μ thick, composed of loosely interwoven hyphae up to 5–8 μ in diameter, not incrusted, only very rarely nodose-septate; cystidia incrusted, 40–100 × 8–15 μ, wholly immersed in the hymenial tissue or protruding up to 50 μ; spores white in spore falls, even, 4½–5½ × 2½–3 μ.

Fructifications 3–20 cm. long, 2–15 cm. broad.

On decaying limbs and logs of such frondose species as *Fagus, Quercus, Castanea, Populus*, etc., more rarely on coniferous wood. Throughout Canada and the United States and in Europe. May to December. Frequent.

P. velutina may be recognized by its large and rather thick fructifications of pinkish or vinaceous color when dry, separable from the substratum when moistened, by frequent presence of marginal mycelial strands, and by the coarse, non-incrusted hyphae—often up to 8 μ in diameter—present in sectional preparations near the substratum.

Specimens examined:

Sweden: *L. Romell, 121, 133;* Stockholm, *L. Romell, 137.*

Poland: *Eichler*, from Bresadola.

Austria: Tirol, *V. Litschauer.*

France: Cormatin, *F. Guillemin, 10,* in part; St. Priest, Allier, *H. Bourdot, 20859.*

Canada: *J. Macoun, 231,* comm. by W. G. Farlow (in Mo. Bot. Gard. Herb., 14763); Ontario, Casselman, *J. Macoun, 366.*

New Hampshire: Chocorua, *W. G. Farlow, 71* (in Mo. Bot. Gard. Herb., 43973).

Vermont: Ripton, *E. A. Burt.*

Massachusetts: *R. J. Blair,* comm. by L. O. Overholts, 3812 b (in Mo. Bot. Gard. Herb., 54994).

New York: Alcove, *C. L. Shear, 1198;* East Galway, *E. A. Burt,* two gatherings: Floodwood, *C. H. Peck* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 55967), *E. A. Burt*; Karner, *H. D. House* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 54393).

New Jersey: Alpine, *P. Wilson, 29* (in Mo. Bot. Gard. Herb., 54748).

Pennsylvania: State College, *L. O. Overholts, 3326* (in Mo. Bot. Gard. Herb., 9533).

Alabama: Montgomery County, *R. P. Burke, 419* (in Mo. Bot. Gard. Herb., 57259).

Tennessee: Elkmont, *C. H. Kauffman, 73* (in Mo. Bot. Gard. Herb., 54330).

Michigan: New Richmond, *C. H. Kauffman, 54* (in Mo. Bot. Gard. Herb., 11996); Seney, *C. J. Humphrey, 1596* (in Mo. Bot. Gard. Herb., 17541).

Wisconsin: Madison, *C. J. Humphrey, 2156* (in Mo. Bot. Gard. Herb., 6729).

Illinois: Anna, *C. J. Humphrey, 2044* (in Mo. Bot. Gard. Herb., 21525).

Montana: Bernice, *E. E. Hubert,* comm. by J. R. Weir (in Mo. Bot. Gard. Herb., 63250); Yellowstone, *F. S. Wolpert,* comm. by J. R. Weir, 3934 (in Mo. Bot. Gard. Herb., 55179).

Colorado: Pike's Peak, *G. G. Hedgcock,* comm. by C. J. Humphrey, 2543 (in Mo. Bot. Gard. Herb., 20783).

Idaho: Priest River, *J. R. Weir, 618* (in Mo. Bot. Gard. Herb., 63200).

British Columbia: Kootenai Mts., near Salmo, *J. R. Weir, 512* (in Mo. Bot. Gard. Herb., 3772); Sidney, *J. Macoun, 34, 42* (in Mo. Bot. Gard. Herb., 55341, 55345).

Washington: Bingen, *W. N. Suksdorf, 703.*

Oregon: Grant's Pass, *J. R. Weir, 8687* (in Mo. Bot. Gard. Herb., 63199).

New Mexico: Tyom Experiment Station, *W. H. Long, 21898* (in Mo. Bot. Gard. Herb., 55121).

46. **P. affinis** Burt, n. sp.

Name without description in Peck, N. Y. State Mus. Bul. **54**: 954. 1902.

Type: in Burt Herb.

Fructifications broadly effused, membranaceous, adnate, separable when moistened, drying light buff to pinkish buff and light pinkish cinnamon, often cracked and showing the paler subiculum in the crevices, the margin paler, radiately fibrillose; in section not colored, 300–500 μ thick, with the hyphae hyaline, 3–5 μ in diameter, not at all incrusted, arranged densely and longitudinally in a broad layer along the substratum and then ascending obliquely into the hymenial layer; cystidia incrusted or not incrusted, 30–60 × 5–8 μ, protruding up to 30 μ, occurring in the hymenial layer only; spores white in a spore collection, even, 4½–6 × 2½–3 μ.

Fructifications 3–20 cm. long, 2–4 cm. broad.

On bark and decorticated logs and limbs of frondose species. Canada to New York and westward to Oregon, and also in Europe. July to October. Common.

P. affinis is related in aspect to *P. laevis* and has hyphae of the same diameter and arrangement as those of the latter species but not at all incrusted. The fructifications of *P. affinis* are usually thicker than those of *P. laevis*, less adnate to the substratum, paler and more cracked. Pale specimens of *P. sanguinea* crack into somewhat similar areas but show a somewhat colored, floccose subiculum in the fissures. The hyphae of *P. affinis* are of smaller diameter than those of *P. velutina*.

Specimens examined:

Exsiccati: Reliq. Farlowianae, 343, under the name *Peniophora laevis*.

Sweden: *L. Romell, 123, 124,* both under the name *P. velutina*.

Austria: Tirol, *V. Litschauer*, under the name *P. laevis*.

France: Allier, *H. Bourdot, 8579,* under the name *P. laevis*.

Canada: *J. Macoun, 76,* comm. by N. Y. State Mus. Herb. (in Mo. Bot. Gard. Herb., 57510).

Quebec: Hull, *J. Macoun, 220.*

Ontario: Jefferson, *G. H. Graham*, comm. by Univ. Toronto Herb., 674 (in Mo. Bot. Gard. Herb., 44924).

Maine: Kittery Point, *R. Thaxter & E. A. Burt.*

New Hampshire: Chocorua, *W. G. Farlow, 35* and two unnumbered specimens in Burt Herb., Reliq. Farlowianae, 343, and *C 36, 41, 69* (in Mo. Bot. Gard. Herb., 43964, 43969, 43970 respectively), *E. A. Burt,* three gatherings; North Conway, *L. O. Overholts, 5106* (in Mo. Bot. Gard. Herb., 56356).

Vermont: Middlebury, *E. A. Burt,* type and another gathering.

Massachusetts: North Scituate, *W. G. Farlow.*

New York: Albany, *H. D. House* (in N. Y. State Mus. Herb. and Mo. Bot. Gard. Herb., 14835); East Galway, *E. A. Burt,* six gatherings; Jamesville, *L. M. Underwood* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 63419); Karner, *H. D. House* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 54348, 54352, 54371); Oneida, *H. D. House* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 59681); Snyder, *C. H. Peck* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 55757); Syracuse, *L. M. Underwood, 116* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61485); West Fort Ann, *S. H. Burnham, 12* (in Mo. Bot. Gard. Herb., 44002).

Tennessee: Elkmont, *C. H. Kauffman, 68* (in Mo. Bot. Gard. Herb., 1680).

Illinois: Glencoe, *E. T. & S. A. Harper, 650, 820.*

Wisconsin: Madison, *C. J. Humphrey, 2159* (in Mo. Bot. Gard. Herb., 4597).

Oregon: Corvallis, *W. A. Murrill, 1011,* comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 55714).

Jamaica: *Farr, 1617* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61489). This reference is doubtful for the hymenium is in poor condition.

47. P. inflata Burt, n. sp.

Type: in Burt Herb. and probably in N. Y. Bot. Gard. Herb.

Fructifications effused, thin, tender, soft, membranaceous, separable, brittle when dry and cream color to cream-buff, the subiculum and margin white and cottony; in section 150 μ thick, not colored, 2-layered, consisting of (1) a layer next to substratum 75 μ thick of loosely arranged, thin-walled, lax, hyaline hyphae $2\frac{1}{2}$–3 μ in diameter bearing short lateral branches, each with 2

moniliform inflations, and of (2) a hymenial layer of erect hyphae densely arranged, and of numerous cystidia in all regions of this layer; no gloeocystidia; cystidia incrusted or not incrusted, 15–24 × 3–3½ μ, protruding up to 18 μ beyond the basidia; spores colorless, even, 3 × 2–2½ μ, flat on one side, copious.

Fructifications 3–4 cm. long, 1–1½ cm. wide.

On very rotten wood. Jamaica. December. Probably rare.

P. inflata is so loosely attached to the substratum that careful handling is necessary to prevent fructifications from becoming detached from the wood during examination. The pair of moniliform inflations on short lateral branches of hyphae of the hyphal layer shows distinctly in sectional preparation and promises to be as helpful a character in the recognition of this species as the details of hyphal structure in *Stereum purpureum*, *Corticium investiens*, *Grandinia granulosa*, and others.

Specimens examined:

Jamaica: Hope Gardens, *W. A. Murrill*, *4*, type, comm. by N. Y. Bot. Gard. Herb.

48. P. Sheari Burt, n. sp.

Type: in Burt Herb.

Fructification effused, rather thick, membranaceous, drying pinkish buff, somewhat tubercular, somewhat velvety, not waxy, the margin becoming somewhat free and curling up in drying, separable from the substratum when moistened; in section 800–1000 μ thick, not colored, 2-layered, the layer next to the substratum up to 800–900 μ broad and composed of densely interwoven, hyaline hyphae not incrusted, not nodose-septate, thick-walled, 3 μ in diameter, the hymenial layer 100–150 μ broad, containing throughout great numbers of slender, rough-walled or minutely incrusted cystidia 30–45 × 4–6 μ; no gloeocystidia; basidia with 4 sterigmata; spores hyaline, even, 10–12 × 6–7 μ.

Fructifications 3 mm.–2 cm. in diameter.

On dead *Alnus*. Blue Mt., Oregon. August. Probably rare and local.

The fructifications apparently originate as outgrowths from lenticels in the bark and spread laterally over more or less circular areas and become confluent. The occurrence on *Alnus*, tuber-

cular surface, numerous and small cystidia confined to the hymenial layer, and spores 12 × 6 μ form a distinctive group of characters.

Specimens examined:

Oregon: Blue Mt., *C. L. Shear, 797*, type.

49. P. Ravenelii Cooke, Grevillea **8**: 21. *pl. 124, f. 12.* 1879; Sacc. Syll. Fung. **6**: 643. 1888; Massee, Linn. Soc. Bot. Jour. **25**: 150. 1889.

Type: in Kew Herb.

Fructifications broadly effused, adnate, thin, small pieces separable when moistened, becoming pale pinkish buff to pinkish buff in the herbarium, and somewhat cracked, the margin thinning out; in section 100–300 μ thick, not colored, composed of erect and densely interwoven hyaline hyphae and very numerous cystidia in all regions of the fructifications and having a somewhat layered arrangement in thick specimens; no gloeocystidia; cystidia heavily and coarsely incrusted, conical, with apex obtuse or barely acute, 30–40 × 12–18 μ when deeply immersed, or 30 × 8–10 μ in the hymenium; spores white in a spore collection, even, 4–5 × 2–3 μ.

Fructifications 2–8 cm. long, 1–3 cm. wide.

On bark and wood of decaying logs of *Quercus* and other frondose species. District of Columbia to Mexico, in the Island of Guam, and in Japan. July to January. Frequent.

P. Ravenelii is distinguished by its small spores, coarsely incrusted, short cystidia with broad base, and absence of gloeocystidia. *P. Roumeguerii* is similar in aspect but becomes much thicker and has longer, slenderer, and more taper-pointed cystidia and is more distinctly layered.

Specimens examined:

Exsiccati: Ravenel, Fungi Am., 720, under the name *Corticium laeve;* Ravenel, Fungi Car. **2**: 39, under the name *Corticium laeve.*

District of Columbia: Takoma Park, *C. L. Shear, 1345.*

South Carolina: *H. W. Ravenel*, type (in Kew Herb.), and in Ravenel, Fungi Car. **2**: 39.

Georgia: Darien, *H. W. Ravenel*, in Ravenel, Fungi Am., 720;

Tallulah Falls, *A. B. Seymour*, comm. by W. G. Farlow, 13 (in Mo. Bot. Gard. Herb., 44597).

Florida: Brooksville Hammock, *W. A. Murrill, 166*, comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 62115); Cocoanut Grove, *R. Thaxter, 96* (in Farlow Herb., and Mo. Bot. Gard. Herb., 43924); Daytona, *R. A. Harper, 7* (in Mo. Bot. Gard. Herb., 54539); New Smyrna, *W. A. Murrill, 6*, comm. by N. Y. Bot. Gard. Herb., 62087.

Alabama: Auburn, *F. S. Earle & C. F. Baker* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61345).

Louisiana: Bogalusa, *C. J. Humphrey, 5495* (in Mo. Bot. Gard. Herb., 13882); St. Martinville, *A. B. Langlois, 2689, 2693* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61457, 61436), and *2692, ar, as, bp, bs, ci,* and *co.*

Mexico: Orizaba, *W. A. & E. L. Murrill, 765*, comm. by N. Y. Bot. Gard. Herb., 54647.

Island of Guam: *Edwards*, comm. by J. R. Weir, 10775 (in Mo. Bot. Gard. Herb., 56239).

Japan: Prov. Awaji, Mt. Mikuma, *A. Yasuda, 39, 56, 79* (in Mo. Bot. Gard. Herb., 56156, 56159, 56313).

50. P. Roumeguerii Bresadola in litt., n. comb.

Corticium Roumeguerii Bresadola, Fungi Trid. **2**: 36. *pl. 144, f. 1.* 1892; Roumeguère, Rèv. Myc. **15**: 31 pag. sep. *pl. 136, f. 13 b.* 1893; Sacc. Syll. Fung. **11**: 125. 1895.—*Kneiffia Roumeguerii* Bresadola, Ann. Myc. **1**: 102. 1903.—*Corticium Mollerianum* Bresadola in Saccardo, Soc. Brot. Bol. **11**: 13. 1892.—*Peniophora Molleriana* (Bres.) Saccardo, Soc. Brot. Bol. **11**: 13. 1892; Sacc. Syll. Fung. **11**: 128. 1895; v. Höhnel & Litschauer, K. Akad. Wiss. Wien Sitzungsber. **117**: 1092. 1908; Bourdot & Galzin, Soc. Myc. Fr. Bul. **28**: 401. 1913; Wakefield, Brit. Myc. Soc. Trans. **5**: 132. 1915; Rea, Brit. Basid. 693. 1922.

Type: type distribution in Roumeguere, Fungi Gallici, 506.

Fructifications broadly effused, adnate, becoming rather thick, small pieces separable when moistened, whitish at first, becoming pale pinkish buff to pinkish buff in the herbarium, the margin thinning out; in section 100–700 μ thick, not colored, becoming

layered in thick specimens, composed of erect and interwoven, closely agglutinate hyphae 2–3 μ in diameter and of very numerous cystidia; no gloeocystidia; cystidia incrusted, 35–80 × 8–12 μ, acute, numerous in all layers except next to the substratum; spores hyaline, even, 4–6 × 2–3 μ.

Fructifications 3–8 cm. long, 1–4 cm. wide.

On bark of logs of *Quercus*, *Eucalyptus*, *Citrus*, *Ficus*, and other frondose species, rarely on conifers. In Europe, and in Alabama, Louisiana, Missouri, Idaho, British Columbia to California, and in the West Indies. May to February. Not common.

P. Roumeguerii is possibly a synonym of *P. Ravenelii*, as I formerly regarded it, but the numerous specimens which have been studied lead me to believe that while of the same aspect, spore characters, and substratum, *P. Roumeguerii* eventually becomes twice as thick as *P. Ravenelii*, more closely agglutinate, and its cystidia longer and slenderer in proportion to their thickness. The error of v. Höhnel & Litschauer, *loc. cit.*, in misstating the year of publication of *P. Molleriana* as 1891 has probably led more recent European authors into reducing *P. Roumeguerii* to synonymy while it really has priority.

Specimens examined:

Locality not stated: *G. Bresadola*, authentic specimen under the name *Peniophora Roumeguerii* Bres.

Italy: Trient, *G. Bresadola*, authentic specimen of *Peniophora Molleriana*.

France: Aveyron, *A. Galzin, 17908*, comm. by H. Bourdot, 16898.

England: Symond's Yat, *E. M. Wakefield* (in Mo. Bot. Gard. Herb., 44759).

Alabama: Montgomery County, *R. P. Burke, 364* (in Mo. Bot. Gard. Herb., 57232).

Louisiana: Baton Rouge, *Edgerton & Humphrey*, comm. by C. J. Humphrey, 5646, 5648; St. Martinville, *A. B. Langlois, 1346*, comm. by W. G. Farlow, 2675, 2683, 2970, cj, ck, and another specimen, comm. by Lloyd Herb., 3042.

Missouri: Creve Coeur Lake, *L. O. Overholts, 3165* (in Mo. Bot. Gard. Herb., 5709).

Idaho: Santa, *E. E. Hubert*, comm. by J. R. Weir, 12001 (in Mo. Bot. Gard. Herb., 63363).

British Columbia: Sidney, *J. Macoun, 379* (in Mo. Bot. Gard. Herb., 55330).

Oregon: Tidewater, *S. M. Zeller, 1983* (in Mo. Bot. Gard. Herb., 58760).

California: Berkeley, *C. J. Humphrey, 5987, 5990;* Redding, *C. J. Humphrey, 6038;* Santa Barbara, *O. M. Oleson, 10.*

Cuba: *Horne* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61464).

Porto Rico: Rio Piedras, *J. A. Stevenson, 5792* (in Mo. Bot. Gard. Herb., 54693); Sabana Llana, *J. A. Stevenson, 6058* (in Mo. Bot. Gard. Herb., 54686); Vega Baja, *J. A. Stevenson, 5693* (in Mo. Bot. Gard. Herb., 54692).

51. P. hiulca Burt, n. sp.

Type: in Burt Herb. and probably in N. Y. Bot. Gard. Herb.

Fructifications long and widely effused, thick, membranaceous, separable when moistened, becoming light buff to warm buff in the herbarium, widely cracked, the margin determinate, somewhat tomentose; in section 250–1400 μ thick, not colored, 2-layered, with a very thick layer next to the substratum of densely interwoven, longitudinally arranged and somewhat ascending thin-walled, hyaline hyphae 3–4 μ in diameter, not incrusted, not nodose-septate and with the hymenial layer thinner—only 100–200 μ thick—and containing in all portions very numerous cystidia; no gloeocystidia; cystidia incrusted, somewhat conical, 30–50 × 6–12 μ, very numerous, wholly immersed or protruding up to 30 μ; basidia with 4 sterigmata; spores hyaline, even, $4\frac{1}{2}$–5 × 3 μ.

Fructifications 4–12 cm. long, 2–4 cm. wide—perhaps larger for all specimens received are fragmentary.

On bark and decaying wood of frondose species. Mexico and the West Indies. November to May.

P. hiulca has large, conspicuous fructifications with somewhat the color and aspect of *P. mutata* and *P. Roumeguerii.* The absence of gloeocystidia and the smaller spores distinguish it from the former, and the comparatively thin hymenial layer to which cystidia are restricted and the very thick layer of interwoven hyphae running in all directions, rather than predominantly erect, from *P. Roumeguerii.*

Specimens examined:

Mexico: Jalapa, *W. A. & E. L. Murrill, 192*, comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 54549).

Bermuda: *S. Brown, N. L. Britton & F. J. Seaver, 1507*, comm. by N. Y. Bot. Gard. Herb.

Jamaica: Castleton Gardens, *W. A. & E. L. Murrill, 71*, type, comm. by N. Y. Bot. Gard. Herb.; Mandeville, *A. E. Wight*, comm. by W. G. Farlow.

52. P. phosphorescens Burt, n. sp.

Type: in Burt Herb. and probably in Farlow Herb.

Fructifications effused, membranaceous, separable, becoming clay-color to avellaneous in the herbarium, and widely cracked into rectangular portions about 5 mm. in diameter, which curl up somewhat from the substratum along the fissures and show the whitish, cottony subiculum, the hymenium waxy, somewhat tubercular and minutely spotted in the type, the margin thinning out; in section 300–500 μ thick, not colored, 2-layered, with the layer next to the substratum composed of loosely interwoven hyphae 3–3½ μ in diameter, the hymenial layer up to 200 μ thick, composed of densely arranged hyphae and cystidia; no gloeocystidia; cystidia incrusted, 70–100 × 12–18 μ, fusiform, acute, sometimes tilted, immersed throughout the hymenial layer, few protruding; spores hyaline, even, subglobose, 4–5 × 3–3½ μ; said to be phosphorescent when collected.

Fructifications probably large, for collections consist of fragments 7 × 1½ cm., and 1½–3 cm. in diameter.

On rotten wood of fence post and decaying bark of frondose species. Jamaica. October to December.

P. phosphorescens may be recognized by the thick, clay-colored fructifications which contract in drying so as to crack into rectangular masses about 5 mm. in diameter, separated from one another by rather wide fissures. The thick, hymenial portion of each mass is so weakly attached to the substratum by the loose subiculum that these masses curl upward along their edges and may occasionally become wholly detached. The cystidia are suggestive of those of *P. flavido-alba* but all other characters of these two species are different. Phosphorescence has been recorded for but few fungi.

Specimens examined:

Jamaica: *A. E. Wight*, type, comm. by W. G. Farlow; Castleton Gardens, *F. S. Earle, 240*, comm. by N. Y. Bot. Gard. Herb.

53. P. sanguinea (Fr.) Bresadola in v. Höhnel & Litschauer, K. Akad. Wiss. Wien Sitzungsber. **115**: 1588, 1589. 1906; Bourdot & Galzin, Soc. Myc. Fr. Bul. **28**: 395. 1913; Rea, Brit. Basid. 690. 1922.

Thelephora sanguinea Fries, Elenchus Fung. **1**: 203. 1828.—*Corticium sanguineum* Fries, Epicr. 561. 1838; Hym. Eur. 650. 1874; Icones Hym. **2**: 97. *pl. 198, f. 2.* 1877; Sacc. Syll. Fung. **6**: 612. 1888; Wakefield, Brit. Myc. Soc. Trans. **4**: 119. *pl. 3, f. 18–20.* 1913.—*Kneiffia sanguinea* (Fries) Bresadola, Ann. Myc. **1**: 101. 1903.—*Corticium glabrum* Berkeley & Curtis, Grevillea **1**: 178. 1873; Sacc. Syll. Fung. **6**: 620. 1888; Massee, Linn. Soc. Bot. Jour. **27**: 142. 1890.—(In part) *Corticium Petersii* Berkeley & Curtis, Grevillea **1**: 177. 1873.

Fructification effused, somewhat membranaceous, tender, dragon's-blood red, substance arachnoid, the margin byssoid or fibrillose and often connected with mycelial strands of blood-red color which stain the wood red, hymenium drying light buff and pinkish buff to buff-pink; in section 200–500 μ thick, not colored, with the hyphae loosely arranged, 3–6 μ in diameter, and with some granule-incrusted, rarely nodose-septate; cystidia hair-like, not incrusted usually, about 4½ μ in diameter, protruding 20–30 μ; spores white in spore collection, even, 4–5 × 2–2½ μ.

Fructifications 2–10 cm. long, 1–4 cm. wide.

On dead wood and fallen branches especially of conifers. Europe, New Hampshire to Louisiana, and in Oregon. July to January. Infrequent.

P. sanguinea and *P. miniata* may be recognized by the blood-red color of the young fructifications, the more or less numerous red mycelial strands, and the wood stained red. Later in fertile stage the hymenium tends toward a buff color with a tinge of red. In section *P. sanguinea* shows granule-incrusted hyphae more or less numerous among other even-walled hyphae, while *P. miniata* contains no incrusted hyphae.

Specimens examined:

Exsiccati: Ell. & Ev., Fungi Col., 1020, under the name *Corticium radiosum.*

Sweden: *L. Romell, 130;* Stockholm, *L. Romell, 136.*

Austria: Tirol, *V. Litschauer.*

France: *F. Fautrey,* from Lloyd Herb., 3308.

New Hampshire: Chocorua, *W. G. Farlow, 10, E. A. Burt, 3, 4.*

New York: Hudson Falls, *S. H. Burnham, 21* (in Mo. Bot. Gard. Herb., 54490); Karner, *H. D. House, 14.157* (in Mo. Bot. Gard. Herb., 44704); Oneida, *H. D. House* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 57434); Wymantskill, *C. H. Peck* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 56051).

New Jersey: Newfield, *J. B. Ellis,* in Ell. & Ev., Fungi Col., 1020.

Pennsylvania: State College, *L. O. Overholts, 3422* (in Mo. Bot. Gard. Herb., 54476).

South Carolina: Society Hill, types of *Corticium glabrum,* Curtis Herb., 2404 (in Curtis Herb.) and 3719 (in Kew Herb.).

Florida: *W. W. Calkins, 845* (in Burt Herb., Farlow Herb., and Mo. Bot. Gard. Herb., 63421).

Alabama: *Peters, 847,* under the name *Corticium miniatum* (in Curtis Herb., 5225), and *Peters, 473,* one of the types of *Corticium Petersii* (in Curtis Herb., 4509).

Louisiana: St. Martinville, *A. B. Langlois, 2704.*

Oregon: Corvallis, *S. M. Zeller, 1860* (in Mo. Bot. Gard. Herb., 56868).

54. P. limonia Burt, n. sp.

Type: in Mo. Bot. Gard. Herb.

Fructifications broadly effused, compact, fleshy-membranaceous, small pieces separable when moistened, cream-buff, not cracked, the margin byssoid and with some radiating, cream-buff mycelial strands; in section 200 μ thick, not perceptibly colored, 2-layered next to the substratum, with very coarse, heavily incrusted, loosely arranged, longitudinally interwoven hyphae 6–9 μ in diameter, and with the hymenial layer 75 μ thick and composed of erect tissues; no gloeocystidia; cystidia not incrusted, 45 × 4½ μ, tapering to a sharp apex, protruding 20–27 μ beyond the basidia; spores hyaline, even, 3–4 × 2½ μ.

Fructifications 2½–4 cm. long, 1–1½ cm. wide.

On bark of decaying *Robinia neo-mexicana*. New Mexico. August.

P. limonia has the color of *P. sulphurina* and *P. carnosa* but differs from both by its occurrence on frondose bark and very coarse, heavily incrusted hyphae. The hymenial layer does not crack and flake away from the substratum like that of *P. sulphurina.* Treatment of sections with potassium hydrate solution causes no color changes.

Specimens examined:

New Mexico: Sulphur Canyon, *W. H. Long*, *21405*, type (in Mo. Bot. Gard. Herb., 55146).

55. P. amoena Burt, n. sp.

Type: in Mo. Bot. Gard. Herb.

Fructifications long and broadly effused, thin, adnate, small pieces separable when moistened, cream-color in the herbarium, even, glabrous, the margin thinning out, of finely interwoven hyphae; in section 120 μ thick, not colored, with the hyphae near the substratum compactly interwoven, about 3 μ in diameter; an incrusted subhymenial zone present, formed of numerous incrusted bodies side by side; no gloeocystidia; cystidia of the hymenial surface not incrusted, 7–9 μ in diameter, protruding up to 45 μ; basidia rather large, 25–30 × 5–6 μ, with 4 sterigmata; spores hyaline, even, 12–15 × 4–6 μ, copious.

Fructifications probably large, for pieces broken off at one end and one side are 5–6 cm. long, 1½–2 cm. wide.

On a soft wood of a frondose species. British Columbia.

P. amoena forms cream-colored, somewhat waxy fructifications on decorticated logs of a pale soft wood—perhaps *Populus.* The spores are so large as to afford a valuable specific character.

Specimens examined:

British Columbia: Sidney, *J. Macoun*, *7*, type (in Mo. Bot. Gard. Herb., 5766).

56. P. firma Burt, n. sp.

Type: in Burt Herb.

Fructifications effused, rather thick, dry, firm, membranaceous,

small pieces separable when moistened, cream-buff in the herbarium, even, not cracked, the margin thinning out, fibrillose; in section 300–500 μ thick, not colored, with the hyphae 4–6 μ in diameter near the substratum, densely interwoven, ascending and becoming finer, sometimes incrusted towards the hymenial layer; no gloeocystidia; cystidia not incrusted, tapering upward to a sharp point, 4–5 μ at base, protruding 20–35 μ, confined to surface of hymenium, numerous; spores hyaline, even, 4–5 × 2½–3 μ.

Fructifications 2–5 cm. long in pieces broken off at both ends, 3–5 cm. wide.

On rotten wood of *Alnus* (?) and on bark of *Robinia neomexicana*. Washington and Arizona. September and October.

P. firma resembles *P. Roumeguerii* in general aspect but its cystidia are slenderer than those of *P. Roumeguerii*, not incrusted, and present in the hymenial surface only.

Specimens examined:

Washington: Arlington, *C. J. Humphrey, 7609*, type.

Arizona: Santa Catalina Mountains, Coronado National Forest, *G. G. Hedgcock & W. H. Long*, comm. by C. J. Humphrey, 2555 (in Mo. Bot. Gard. Herb., 12262).

57. P. miniata (Berk.) Burt, n. comb.

Thelephora miniata Berkeley in Hooker, Eng. Flora 2[2]: 168. 1836; Brit. Fungi, No. 251. 1843. See v. Höhnel & Litschauer, K. Akad. Wiss. Wien Sitzungsber. **115**: 1588. 1906.

Type: authentic specimen in Berkeley, Brit. Fungi, 251.

Fructification effused, somewhat membranaceous, tender, English red, substance arachnoid, the margin byssoid or fibrillose and often connected with mycelial strands of blood-red color; hymenium drying pinkish buff to buff-pink and cinnamon-rufous; in section 150–300 μ thick, not colored, the hyphae loosely arranged, 3–6 μ in diameter, not incrusted, rarely nodose-septate; cystidia few, hair-like, not incrusted, 3½–4½ μ in diameter, protruding 20–30 μ; spores hyaline, even, 4–4½ × 2–2½ μ.

Fructifications 2–10 cm. long, 1–2½ cm. broad.

On fallen limbs, usually of conifers. In England, New Hampshire to Louisiana, and in Washington and Oregon. July to December. Infrequent.

The twenty gatherings cited below have been separated from *P. sanguinea* by the absence of incrusted hyphae in their sectional preparations. In the original description of *T. miniata*, Berkeley stated, "This most elegant species differs so much from *T. sanguinea* Fr., in being most highly colored where exposed to light, while in the portions to which light has not free access it is nearly white, and in not tinging the wood whereon it grows with its own color, that an inspection of specimens renders it almost impossible to consider it the same." Fifteen of the twenty specimens referred below to *P. miniata* on account of absence of hyphal incrustation have the hymenium red and only five pinkish buff, while none of the twenty specimens show the wood stained red.

Specimens examined:

Exsiccati: Berkeley, Brit. Fungi, 251, authentic specimen of *Thelephora miniata* Berk.

England: Berkeley, Brit. Fungi, 251.

New Hampshire: Chocorua, *E. A. Burt, 1, 2.*

New York: Albany, *H. D. House* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 14830, 55201), and *H. D. House & J. Rubinger* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 17797); Karner, *H. D. House*, comm. by N. Y. State Mus. Herb. (in Mo. Bot. Gard. Herb., 54347, 54357, 54377); Newtonville, *C. H. Peck* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 55969, 55989); North Elba, *C. H. Kauffman, 5* (in Mo. Bot. Gard. Herb., 6719); Schuylerville, *C. H. Peck*, comm. by N. Y. State Mus. Herb., T 17, T 25 (in Mo. Bot. Gard. Herb., 54570, 54657).

Georgia: Tallulah Falls, *A. B. Seymour*, from Farlow Herb., D (in Mo. Bot. Gard. Herb., 44609).

Louisiana: St. Martinville, *A. B. Langlois, bu.*

Washington: Chehalis, *C. J. Humphrey, 6273;* Hoquiam, *C. J. Humphrey, 6409.*

Oregon: Granite Pass, *J. R. Weir, 11183* (in Mo. Bot. Gard. Herb., 63252).

58. P. Burtii Romell, n. sp.

Type: in Burt Herb. and Romell Herb.

Fructifications effused, somewhat membranaceous, tender, hymenium drying warm buff usually but sometimes whitish to cartridge-buff, sometimes cracked and showing the cottony substance, the margin byssoid or fibrillose and sometimes connected with antimony-yellow mycelial strands; in section 200–300 μ thick, not colored, with the hyphae loosely arranged, hyaline, rarely nodose-septate, with some incrusting granules in the subhymenium; cystidia hair-like, not incrusted, tapering, 3–4 μ in diameter, protruding up to 25 μ, not numerous; spores hyaline, even, 4–4½ × 2–2½ μ.

Fructifications 2–7 cm. long, 1–2 cm. broad.

On wood and fallen limbs of frondose species in woods. Vermont to Louisiana and in Ohio, Michigan, and Montana. July to October. Rare.

This species is noteworthy by the antimony-yellow or ochraceous mycelial strands or cords which grow from under the bark and connect with the fructifications. The presence of cystidia separates this species from *Corticium sulphureum* which has yellower fructifications and not as large mycelial cords when present.

Specimens examined:

Exsiccati: Ellis, N. Am. Fungi, 933, under the name *Corticium radiosum.*

Vermont: Middlebury, *E. A. Burt.*

Massachusetts: Sharon, *A. P. D. Piguet, 136,* comm. by Farlow Herb. (in Mo. Bot. Gard. Herb., 59627).

New York: Ithaca, *H. H. Whetzel,* comm. by Cornell Univ. Herb., 13760.

New Jersey: Newfield, *J. B. Ellis,* in Ellis, N. Am. Fungi, 933.

Virginia: Crabbottom, *W. A. Murrill, 239* (in N. Y. Bot. Gard. Herb., Burt Herb., and Mo. Bot. Gard. Herb., 61560).

Alabama: Auburn, *Alabama Biological Survey.*

Louisiana: Bogalusa, *C. J. Humphrey, 5472;* St. Martinville, *A. B. Langlois, cl.*

West Virginia: Paw Paw, *C. L. Shear, 1179.*

Ohio: *C. G. Lloyd, 3823,* type.

Michigan: New Richmond, *C. H. Kauffman, 34* (in Mo. Bot. Gard. Herb., 23060).

Montana: Evaro, *J. R. Weir, 415* (in Mo. Bot. Gard. Herb., 14772).

59. P. subapiculata (Bres.) Burt, n. comb.

Corticium subapiculatum Bresadola, Mycologia **17**: 69. 1925.

Type: in Weir Herb.

Fructifications broadly effused, adnate, small pieces separable when moistened, waxy, becoming ivory-yellow to pinkish buff in the herbarium, even, only rarely cracked, the margin thinning out, pruinate; in section about 150 μ thick, not colored, composed of interwoven hyaline hyphae 3½–4½ μ in diameter, not incrusted, only rarely nodose-septate; no gloeocystidia; cystidia hair-like, not incrusted, cylindric, obtuse, 3–4½ μ in diameter, protruding 10–40 μ beyond the basidia; spores hyaline, even, 4–6 × 2–3 μ.

Fructifications 8–12 cm. long, 1–4 cm. wide.

On decaying logs of *Pinus*, *Abies*, and *Larix*—usually on the wood. Idaho and British Columbia. June to September.

P. subapiculata resembles *P. Weiri* in color and general aspect but has no gloeocystidia and smaller cystidia and spores.

Specimens examined:

Montana: Evaro, *J. R. Weir, 414* (in Mo. Bot. Gard. Herb., 63720); Kalispell, *E. E. Hubert*, comm. by J. R. Weir, 11957 (in Mo. Bot. Gard. Herb., 63312).

Idaho: Clarkia, *A. S. Rhoades* (in Weir Herb., 16928, type); Coolin, *J. R. Weir, 11086* (in Mo. Bot. Gard. Herb., 63245); Priest River, *J. R. Weir, 52, 130* (in Mo. Bot. Gard. Herb., 63718), and *E. E. Hubert*, comm. by J. R. Weir, 12020 (in Mo. Bot. Gard. Herb., 63375).

British Columbia: Kootenai Mountains, near Salmo, *J. R. Weir, 476* (in Mo. Bot. Gard. Herb., 63719).

60. P. sordida (Karst.) Burt—not in the sense of Brinkmann or Bresadola.

Corticium sordidum Karsten, Soc. pro Fauna et Flora Fennica Meddel. **9**: 65. 1883; Finska Vet.-Soc. Bidrag Natur och Folk **48**: 413. 1889; Sacc. Syll. Fung. **6**: 631. 1888; Massee, Linn. Soc. Bot. Jour. **27**: 140. 1890. Compare v. Höhnel

& Litschauer, K. Akad. Wiss. Wien Sitzungsber. **117**: 1088. 1908.

Type: authentic specimen in Burt Herb.

Fructifications longitudinally effused, small portions separable when moistened, in the herbarium young specimen pale olive-buff and older specimen wood-brown, contracting in drying and cracking into small rectangular masses about 1 mm. in diameter, separated by rather wide crevices and showing the paler floccose subiculum, the margin thinning out; in section 150–300 μ thick, not colored, becoming stratose, each stratum 2-layered, with the layer towards the substratum composed of loosely arranged, suberect, branching hyphae 4½–5 μ, rarely 6 μ, in diameter, not incrusted, not nodose-septate, and the hymenial layer compact, 75 μ thick; no gloeocystidia; cystidia not incrusted, cylindric, obtuse, 4–6 μ in diameter, protruding up to 30 μ, none wholly immersed; spores copious, hyaline, even, 4½–6 × 2–3 μ.

Fructifications 3 cm. × 7 mm. and 2½ × 1 cm. in the two fragmentary pieces from Karsten, 3–10 cm. long, 7–15 mm. wide in an American specimen.

On decorticated wood of *P. sylvestris* and *P. Strobus* on the ground. Finland and New York. October. Rare.

Brinkmann distributed in his "Westfälische Pilze," 8, under the name of *Peniophora sordida* (Karst.) Brinkmann, a specimen which was later referred by Bresadola to *Peniophora serialis*. I have not seen this specimen. Von Höhnel & Litschauer accepted this reference, *loc. cit.*, and placed *Corticium sordidum* Karst. as a synonym of *P. serialis*. The study of other specimens of the *P. serialis* complex shows that none of these others have the structure of authentic *Corticium sordidum* although somewhat resembling the old stage in general aspect. The problem with me for a time was whether *P. cremea* is distinct from *P. sordida*, but *P. cremea* occurs on frondose wood, is not cracked into rectangular, completely separated masses, and has larger cystidia, some of which are incrusted and wholly immersed. The Karsten specimens of *C. sordidum* are in some places composed of a single stratum 150 μ thick of 2 layers and in others of 2 strata with thickness together of 240–300 μ.

Specimens examined:

Finland: Mustiala, *P. A. Karsten*, authentic specimen of *Corticium sordidum*.
New York: Karner, *H. D. House, 14.188* (in Mo. Bot. Gard. Herb., 44722).

61. P. Burkei Burt, n. sp.

Type: in Mo. Bot. Gard. Herb.

Fructifications broadly effused, thin, adnate, membranaceous, tender, small pieces separable when moistened, cream-buff in the herbarium, somewhat tubercular, conforming to the inequalities of the rough bark upon which growing, somewhat cracked in drying, the margin thinning out, of finely interwoven hyphae; in section 120–180 μ thick, not colored, with the hyphae suberect, loosely interwoven, thin-walled, 3 μ in diameter, nodose-septate, not incrusted; no gloeocystidia; cystidia not incrusted, subulate, 50 × 4½–5 μ, protruding up to 20 μ; spores hyaline, even, 6–7 × 4–5 μ, copious.

Fructifications probably large—4 cm. long, 2–2½ cm. wide in pieces broken off at both ends and on one side.

On rough, frondose bark. Alabama. October.

P. Burkei has some resemblance in aspect to *P. cremea* but has a more tubercular hymenium, slenderer and more erect hyphae, and larger spores.

Specimens examined:

Alabama: Montgomery County, *R. P. Burke, 474*, type (in Mo. Bot. Gard. Herb., 57292).

62. P. glebulosa Bresadola, Fungi Trid. **2**: 61. *pl. 170, f. 2.* 1898; Sacc. Syll. Fung. **16**: 195. 1902; Bourdot & Galzin, Soc. Myc. Fr. Bul. **28**: 384. 1913; Rea, Brit. Basid. 688. 1922.

Not *Thelephora calcea* Fries var. *glebulosa* Fries, Elenchus Fung. **1**: 215. 1828.—Not *Corticium calceum* Fries, Epicr. 562. 1838; nor Hym. Eur. 652. 1874.

Type: in Bresadola Herb. and Burt Herb.

Fructifications widely effused, thin, closely adnate, whitish, pinkish buff, pale olive-buff, or cream color, pubescent with the cystidia, becoming cracked into small areas when dry, the margin thinning out; in section 50–200 μ thick, not colored, composed throughout of cystidia and rather erect, interwoven, hyaline,

thin-walled hyphae 1–3 μ in diameter, not incrusted; cystidia thick-walled, with very narrow lumen which is often much larger at apex of cystidium, even where immersed, or sometimes with some granular incrustation near protruding apex, 60–150 × 7–10 μ, protruding up to 50–100 μ, very numerous throughout the fructification, not dissolved by treatment of sections with potassium hydrate; spores white, even, cylindric, slightly curved, 6–9 × 1½–2 μ.

Fructifications 3–15 cm. long, 1–6 cm. wide.

On wood of decaying conifers, rarely on bark, and on frondose species. In Europe, from Canada to New Jersey, in Nebraska, Colorado, Montana and Manitoba to British Columbia and Oregon. May to November. Common locally.

P. glebulosa has distinctive cystidia to which Bourdot & Galzin have given the term cystidioles. These cystidia are elongated, cylindric, even throughout their whole length usually, but sometimes with a little incrusting matter near the apex of the protruding part, and with a very thick wall—so thick that the axial lumen containing protoplasmic contents is merely a line which, however, is often greatly expanded at its peripheral end in the apex of the cystidium where the latter becomes thin-walled and fragile. The cystidia of *P. glebulosa* are not at all dissolved or only partially by the potassium hydrate treatment to which sections are subjected. In the original description Bresadola states that *P. glebulosa* is the same as authentic *Corticium calceum* var. *glebulosum* Fries. I believe this to be an error, for a fragment of authentic *C. calceum* var. *glebulosum* communicated to me by Bresadola and the original specimens so labelled in Fries Herbarium, all of which I studied, have no cystidia whatever and agree in all respects with a true *Corticium* collected at Femsjö, the original station, by Romell and myself.

Specimens examined:

Sweden: Femsjö, *Romell & Burt*, three gatherings; Lappland, *L. Romell, 405;* Stockholm, *L. Romell, 199.*

Austria: Stubai, Tirol, *V. Litschauer.*

Italy: Trient, *G. Bresadola*, type.

England: Symond's Yat, *E. M. Wakefield* (in Mo. Bot. Gard. Herb., 57120).

Canada: Billings Bridge, *J. Macoun, 113.*

Quebec: Hull, *J. Macoun, 246.*

Maine: *W. A. Murrill, 2139½* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61424); Kittery Point, *R. Thaxter & E. A. Burt;* Piscataquis County, *W. A. Murrill, 2142, 2653* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61349, 61441).

New Hampshire: Chocorua, *W. G. Farlow* (in Mo. Bot. Gard. Herb., 19554) and *11.*

Vermont: Middlebury, *E. A. Burt,* four gatherings.

New York: Altamont, *E. A. Burt;* East Galway, *E. A. Burt,* three gatherings; Farmington, *E. Brown, 116* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61451); Ithaca, *G. F. Atkinson, 8236, 8284;* Sandlake, *C. H. Peck,* comm. by N. Y. State Mus. Herb., T 15 (in Mo. Bot. Gard. Herb., 54568).

New Jersey: Newfield, *J. B. Ellis,* under the herbarium name *P. gracillima* (in N. Y. Bot. Gard. Herb., and Burt Herb.).

Nebraska: Long Pine, *C. L. Shear, 1056.*

Colorado: Geneva Creek Canyon, alt. 8000–14000 ft., *F. J. Seaver & E. Bethel* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61467); Golden, *L. O. Overholts, 1752* (in Mo. Bot. Gard. Herb., 54881).

Montana: Bernice, *J. R. Weir, 12000, 12006* (in Mo. Bot. Gard. Herb., 63362, 63366); Darby, *E. E. Hubert,* comm. by J. R. Weir (in Mo. Bot. Gard. Herb., 63248); Hecla, *E. E. Hubert,* comm. by J. R. Weir, 11416 (in Mo. Bot. Gard. Herb., 63263); Libby, *E. E. Hubert,* comm. by J. R. Weir, 11443 (in Mo. Bot. Gard. Herb., 63273).

Idaho: Coeur d'Alene, *J. R. Weir, 11974,* and *E. E. Hubert,* comm. by J. R. Weir, 11991 (both in Mo. Bot. Gard. Herb., 63328 and 63354 respectively); Coolin, *J. R. Weir, 11562* (in Mo. Bot. Gard. Herb., 63301); Priest River, *E. E. Hubert,* comm. by J. R. Weir, 12029 (in Mo. Bot. Gard. Herb., 63381), and *J. R. Weir, 350, 6362* (in Mo. Bot. Gard. Herb., 7853, 55952) and *54.*

Manitoba: Norway House, *G. R. Bisby, 1458, 1464, 1476* (in Mo. Bot. Gard. Herb., 61640, 61646, 61658).

British Columbia: Agassiz, *J. R. Weir, 364* (in Mo. Bot. Gard. Herb., 16407); Comax, *J. Macoun, 622* (in Mo. Bot. Gard. Herb., 55333); Kootenai Mts., Salmo, *J. R. Weir, 485, 538* (in Mo. Bot. Gard. Herb., 17619, 1738); Sidney, *J. Macoun, 22, 41, 64, 97* (in Mo. Bot. Gard. Herb., 5682, 55342, 5742, 55343); Squamish, *J. Macoun* (in Mo. Bot. Gard. Herb., 55180); Vancouver Island, *J. Macoun, 356, 357* (in Mo. Bot. Gard. Herb., 55331, 55332); Victoria, *J. Macoun, 576* (in Mo. Bot. Gard. Herb., 63502).

Washington: Bingen, *W. N. Suksdorf, 699;* Hoquiam, *C. J. Humphrey, 6374;* Kalama, *C. J. Humphrey, 6139;* Renton, *C. J. Humphrey, 6633;* Tacoma, *W. A. Murrill, 145,* comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 55726).

Oregon: Corvallis, *S. M. Zeller, 1813* (in Mo. Bot. Gard. Herb., 56333); Eugene, *C. J. Humphrey, 6086.*

63. P. verticillata Burt, n. sp.

Type: in Mo. Bot. Gard. Herb.

Fructifications effused, thick, membranaceous, separable, whitish to ecru-drab in the herbarium, even the margin whitish, rather thick, cottony; in section 1300 μ thick, not colored, consisting of (a) a layer 500 μ thick next to the substratum of densely, longitudinally arranged hyaline hyphae about 3–3½ μ in diameter, and of (b) a zonate hymenial layer 800 μ thick containing many elongated cystidia; no gloeocystidia; cystidia cylindric, 150–200 × 6–7 μ, with 4–9 bands of incrusting matter, protruding up to 45 μ; no spores found.

Fructifications 1½–2½ cm. long, 1–2 cm. wide.

On rotten coniferous wood. Oregon. March.

The cystidia of *P. verticillata* are of the thick-walled cylindric type occurring in *P. glebulosa* but without as narrow a lumen, nor with the latter abruptly, greatly enlarged near the apex. The bands of incrusting matter on the cystidia are a unique character of the type but are not retained in glycerine mounts of sections. The very broad layer of longitudinally arranged hyphae along the substratum and the very thick, separable fructifications tending to ecru-drab are probably the more distinctive characters of this species, which is distinct from *P.* (*Gloeocystidium*) *pallidula.*

Specimens examined:

Oregon: Waltersville, *C. C. Epling & J. B. Shorett, 600*, type, comm. by S. M. Zeller, 2317 (in Mo. Bot. Gard. Herb., 63041).

64. P. crassa Burt, N. Y. State Mus. Rept. **54**: 155. 1901.

Stereum Karstenii Bresadola, I. R. Accad. Agiati Atti III. **3**: 108. 1897; Bourdot & Galzin, Soc. Myc. Fr. Bul. **37**: 126. 1921.—Not *Peniophora Karstenii* Massee, Linn. Soc. Bot. Jour. **25**: 153. 1889.—Not *Phanerochaete odorata* Karsten, Finska Vet.-Soc. Bidrag Natur och Folk **48**: 427. 1889.—*Corticium ochroleucum*, in part, of Berkeley & Curtis, Grevillea **1**: 165. 1875, but not of Fries.

Type: in Burt Herb.

Fructifications broadly effused, becoming thick, somewhat fleshy, light buff to pinkish buff, separable from the substratum when moistened if thick, the margin somewhat tomentose, determinate; in section 500–1500 μ thick, not colored, 2-layered, with the layer next to the substratum 200–300 μ thick, composed of densely interwoven, rather thick-walled and stiff, non-incrusted hyphae 3–4½ μ in diameter, and with the hymenial layer 300–1200 μ thick, more or less zonate, and composed of erect hyphae and cystidia; no gloeocystidia; cystidia even or sometimes somewhat incrusted, cylindric, flexuous, 100–500 × 4½–6 μ, protruding up to 30 μ beyond the basidia, present in all parts of the hymenial layer, destroyed and dissolved by potassium hydrate treatment of sections; basidia 4-spored; spores white in spore collection, even, curved, 4½–6 × 1½–2 μ.

Fructifications 3–20 cm. long, 1–4 cm. wide.

On decorticated, decaying logs of *Pinus, Abies, Picea, Tsuga*, and *Pseudotsuga*. In Europe and from Canada to Alabama and westward to the Pacific states. Common.

P. crassa is certainly cogeneric with *P. glebulosa*, belongs in the same group of species, occurs on the same substrata and is probably equally destructive to wood. Its fructifications are thicker than those of *P. glebulosa* and crack into larger masses. The cystidia have thinner walls and larger lumen than those of *P. glebulosa* and are noteworthy for the destructive action of potas-

sium hydrate on them, so that it can not be safely used in clearing and swelling the sections. Lactic acid should be used instead.

I have included under *P. crassa* the two European specimens of *Stereum Karstenii* cited below, because of agreement in all characters except the much greater thickness of the latter and their curling away from substratum at the margin and separation of the whole fructification in a sheet-like mass. American specimens of *P. crassa* range from 500 to 1000 μ thick and have the margin closely adnate to the substratum. Perhaps there is specific difference between *P. crassa* and *Stereum Karstenii.*

Specimens examined:

Exsiccati: Ellis, N. Am. Fungi, 331, under the name *Corticium ochroleucum* var. *spumeum;* Ravenel, Fungi Car. 3: 33, under the name *Corticium ochroleucum.*

Hungary: *A. Kmet,* type of *Stereum Karstenii* from Bresadola.

France: Aveyron, *A. Galzin, 20064,* comm. by H. Bourdot, 20799.

Canada: *J. Macoun, 42;* Quebec, *J. Macoun, 260;* Ottawa, *J. Macoun, 248,* in part.

New Hampshire: Chocorua, *W. G. Farlow, 23,* and an unnumbered specimen.

Vermont: Middlebury, *E. A. Burt,* two gatherings; Ripton, *E. A. Burt,* type.

Massachusetts: Magnolia, *W. G. Farlow, e;* Sharon, *A. P. D. Piguet, 139,* comm. by Farlow Herb. (in Mo. Bot. Gard. Herb., 59360).

New York: Floodwood, *E. A. Burt, C. H. Peck, 2;* Ithaca, *G. F. Atkinson, 8008;* Keene, *C. H. Peck,* comm. by N. Y. State Mus. Herb., T 1 (in Mo. Bot. Gard. Herb., 54554); North Elba, *C. H. Peck,* comm. by N. Y. State Mus. Herb., T 9 (in Mo. Bot. Gard. Herb., 54555); Sylvan Beach, Oneida County, *H. D. House* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 7460, 8293).

New Jersey: Newfield, *J. B. Ellis,* in Ellis, N. Am. Fungi, 331.

Pennsylvania: State College, *L. O. Overholts, 3631* (in Mo. Bot. Gard. Herb., 54703).

North Carolina: *H. W. Ravenel, 1521* (in Curtis Herb., 1763, under the name *Corticium ochroleucum* var. *erimosum*).

South Carolina: *H. W. Ravenel,* in Ravenel, Fungi Car. 3: 33,

and (in Curtis Herb., 2169, under the name *Corticium ochroleucum*).

Alabama: Auburn, comm. by Alabama Biological Survey.

Idaho: Addie, *E. E. Hubert*, comm. by J. R. Weir, 11976 (in Mo. Bot. Gard. Herb., 63329); Coolin, *J. R. Weir, 11558* (in Mo. Bot. Gard. Herb., 63299); Priest River, *J. R. Weir, 108, 378, 6351* (in Mo. Bot. Gard. Herb., 16060, 21353, 55951) and *3, 24, 46, 50, 56.*

British Columbia: Kootenai Mts., near Salmo, *J. R. Weir, 455, 498* (in Mo. Bot. Gard. Herb., 8760, 21632); Revelstoke, *C. W. Dodge, 1654* (in Mo. Bot. Gard. Herb., 58788); Sidney, *J. Macoun, 63, 393* (in Mo. Bot. Gard. Herb., 5741, 55325).

Washington: Kalama, *C. J. Humphrey, 6214* (in Mo. Bot. Gard. Herb., 20431).

Arizona: Flagstaff, *W. H. Long, 21386* (in Mo. Bot. Gard. Herb., 55140); Fort Valley Experiment Station, *W. H. Long, 19624* (in Mo. Bot. Gard. Herb., 20133).

65. P. subalutacea (Karst.) v. Höhnel & Litschauer, K. Akad. Wiss. Wien Sitzungsber. **115**: 1601. 1906; Bourdot & Galzin, Soc. Myc. Fr. Bul. **28**: 387. 1913; Wakefield, Brit. Myc. Soc. Trans. **5**: 133. 1914; Rea, Brit. Basid. 688. 1922.

Corticium subalutaceum Karsten, Soc. pro Fauna et Flora Fennica Meddel. **9**: 65. 1883; Finska Vet.-Soc. Bidrag Natur och Folk **48**: 414. 1889; Sacc. Syll. Fung. **6**: 636. 1888; v. Höhnel & Litschauer, K. Akad. Wiss. Wien Sitzungsber. **115**: 1560. 1906.—*Kneiffia subalutacea* (Karsten) Bresadola, Ann. Myc. **1**: 104. 1903.

Type: authentic specimen or perhaps part of type in Burt Herb.

Fructifications long and widely effused, very thin, closely adnate, pale olive-buff to pinkish buff in the herbarium, hymenium loose and rather rough under a lens, the margin thinning out; in section 30–100 μ thick, not colored, with the hyphae interwoven, rather rigid and thick-walled, about 2½ μ in diameter, not incrusted, cylindric, thin-walled, 4½–6 μ, protruding up to 60 μ beyond the basidia, often starting from the substratum, sometimes somewhat clustered at slight elevations of the hymenium;

spores hyaline, even, narrowly cylindric, slightly curved, about $4\frac{1}{2}$–$7 \times 1\frac{1}{2}$ μ.

Fructifications 3–10 cm. long, 1–3 cm. wide.

On decaying pine wood. Europe, New Jersey to Louisiana, and in Washington. July to March. Rare.

The cystidia of *P. subalutacea* place it in the group with *P. glebulosa* and *P. crassa.* It is thinner than either of these. It may be distinguished from thin forms of the former by the thin-walled cystidia which have a lumen of nearly uniform diameter which is not abruptly and greatly enlarged near the apex of the cystidium.

Specimens examined:

Sweden: Femsjö, *E. A. Burt.*

Finland: Mustiala, *P. A. Karsten,* authentic specimen.

Poland: *Eichler,* comm. by G. Bresadola.

Austria: Tirol, *V. Litschauer.*

England: Baslow Foray, *A. D. Cotton,* comm. by E. M. Wakefield (in Mo. Bot. Gard. Herb., 44583).

France: Aveyron, *A. Galzin, 2444,* comm. by H. Bourdot, 8007.

New Jersey: Newfield, *J. B. Ellis, 7510,* comm. by W. G. Farlow (in Mo. Bot. Gard. Herb., 1794).

Maryland: Takoma Park, *C. L. Shear, 1030.*

Alabama: Montgomery County, *R. P. Burke, 635* (in Mo. Bot. Gard. Herb., 63071).

Louisiana: St. Martinville, *A. B. Langlois, 0.*

Washington: Mt. Paddo, *W. N. Suksdorf, 726.*

66. P. odorata (Karsten) Burt, n. comb.

Phanerochaete odorata Karsten, Finska Vet.-Soc. Bidrag Natur och Folk **48**: 427. 1889. Not *Stereum odoratum* Fries, Epicr. 553. 1838.—Not *Stereum Karstenii* Bresadola, I. R. Accad. Agiati Atti III. **3**: 108. 1897.

Type: in Burt Herb. from Karsten and probably in Karsten Herb.

Fructifications narrowly effused, small, pulvinate, somewhat convex, becoming longitudinally confluent, adnate, dry, felty, cartridge-buff to pale pinkish buff, velvety, the margin thick, entire; in section 500–1000 μ thick, not colored, at length zonate

or stratose, composed of a layer next to the substratum of interwoven, tough, hyaline hyphae 3–4 μ in diameter, and of 1–4 hymenial layers; no gloeocystidia; cystidia not incrusted, cylindric, 80–150 × 6–9 μ, protruding up to 80 μ beyond the basidia, not destroyed by potassium hydrate treatment; basidia with 4 sterigmata; spores hyaline, even, 12–15 × 4–6 μ, copious.

Fructifications 5 mm.–2½ cm. long, 3–10 mm. wide, rarely 5–10 cm. long by confluence.

On decorticated decaying wood and fence rails of *Pinus albicaulis*, *P. contorta*, *P. flexilis*, *P. Murrayana*, *P. silvestris*, *Abies grandis*, *Larix*, *Pseudotsuga*, and *Thuja*. In northern Europe, and in Wyoming, Montana, Idaho, British Columbia, Washington, and Arizona. Frequent.

P. odorata may be recognized by its small, thick, pulvinate, dry, velvety, pallid fructifications on old, weathered, blackened, coniferous wood, by large spores, and stratose fructifications which have even cystidia not affected by the potassium hydrate treatment of sections. Karsten referred his specimens to *Stereum odoratum* Fries, and Bresadola included the Karsten specimens under his *Stereum Karstenii* Bres., of which I regard the type to be a gathering made by Kmet in Hungary.

Specimens examined:

Finland: Mustiala, *P. A. Karsten*, type of *Phanerochaete odorata*.

Sweden: Bedaro, *L. Romell, 412;* Lappland, *L. Romell, 413;* Stockholm, *L. Romell, 369.*

Montana: Anaconda, *J. R. Weir, 583* (in Mo. Bot. Gard. Herb., 63173); Bernice, *E. E. Hubert*, comm. by J. R. Weir, 12011 (in Mo. Bot. Gard. Herb., 63322); Hecla, *E. E. Hubert*, comm. by J. R. Weir, 11405 (in Mo. Bot. Gard. Herb., 63260); Choteau, *J. A. Hughes*, comm. by J. R. Weir, 5824 (in Mo. Bot. Gard. Herb., 55649); Libby, *E. E. Hubert*, comm. by J. R. Weir, 11351 (in Mo. Bot. Gard. Herb., 63259); Melrose, *E. E. Hubert*, comm. by J. R. Weir, 11427, 11433, 11439 (in Mo. Bot. Gard. Herb., 63261, 63274, 63279); West Butte, *J. A. Hughes*, comm. by J. R. Weir, 5496 (in Mo. Bot. Gard. Herb., 55647).

Wyoming: Fox Park, *J. R. Weir, 10018* (in Mo. Bot. Gard. Herb., 55789).

Idaho: Bonanza, *G. G. Hedgcock*, comm. by C. J. Humphrey,

2527, in part; Coolin, *J. R. Weir, 11526* (in Mo. Bot. Gard. Herb., 63291); Priest River, *E. E. Hubert*, comm. by J. R. Weir (in Mo. Bot. Gard. Herb., 63258).

British Columbia: Kootenai Mts., Salmo, *J. R. Weir, 536* (in Mo. Bot. Gard. Herb., 22598).

Washington: Mt. Paddo, *W. N. Suksdorf, 729*.

Arizona: Coronado National Forest, Santa Catalina Mountains, *G. G. Hedgcock & W. H. Long*, comm. by C. J. Humphrey, 2544 (in Mo. Bot. Gard. Herb., 63534).

67. P. pilosa Burt, n. sp.

Type: in Burt Herb.

Fructifications effused, thin, closely adnate, hypochnoid, becoming pale olive-buff in the herbarium, the margin thinning out; in section 40–60 μ thick, not colored, composed of loosely arranged, thin-walled hyphae 2½–3 μ in diameter, not incrusted, and of cystidia starting from the substratum; no gloeocystidia; cystidia not incrusted, thin-walled, cylindric, 60–100 × 4½–7 μ, protruding up to 70 μ beyond the basidia, often constricted near the tip and terminating in an ovoid-shaped body; basidia 4-spored; spores hyaline, even, 6–8 × 4–4½ μ, copious.

Fructifications fragmentary, with the largest fragment 2½ cm. long, 1 cm. wide.

On decaying coniferous wood. New York and Alabama. Probably rare.

P. pilosa forms a gray, downy covering on old weathered pine wood, with the basidia not forming a compact hymenium. In aspect this species somewhat resembles *P. tenuis* but there are no gloeocystidia, and the numerous long, cylindric cystidia, sometimes terminating in a single spore-shaped end and sometimes in a short row of 2 or 3, are distinctive.

Specimens examined:

New York: East Galway, *E. A. Burt;* Ithaca, *G. F. Atkinson, 14415*, type.

Alabama: Montgomery, *R. P. Burke, 154* (in Mo. Bot. Gard. Herb., 3650).

68. P. Peckii Burt, n. sp.

Type: in Burt Herb. and probably in N. Y. State Mus. Herb.

Fructifications broadly effused, somewhat membranaceous, separable from the substratum in small portions when moistened, thin, becoming cartridge-buff to cream-buff in the herbarium, not shining, cracking in drying, the margin thinning out; in section 60–360 μ thick, not colored, composed throughout of suberect hyphae about 4 μ in diameter, not incrusted and occasionally nodose-septate, of elongated flexuous cystidia, and of great numbers of subglobose, even chlamydospores $4\frac{1}{2}$–5 × 4 μ; cystidia not incrusted, flexuous, elongated, with somewhat the aspect of gloeocystidia, 30–100 × 6–9 μ, in all regions of fructification, many starting from the substratum, tapering upward, protruding up to 40 μ beyond the basidia; basidia with 4 sterigmata; basidiospores hyaline, even, subglobose, 5–6 × $4\frac{1}{2}$ μ.

Fructifications 2–6 cm. long, 1–3 cm. wide.

On bare ground in woods and on bark and wood of decaying *Alnus*, *Betula*, *Populus*, *Quercus*, and *Ceanothus*, rarely on a coniferous substratum. Canada to Massachusetts and westward to Washington. July to March. Occasional.

P. Peckii is placed in the species group with *P. glebulosa* on account of the large, even-walled cystidia which are more flexuous than those of the latter species and with more the aspect of gloeocystidia, but I have not yet demonstrated by granular contents that they are gloeocystidia. *P. Peckii* is distinguished by the great number of subglobose spores distributed throughout the whole fructification in sections studied.

Specimens examined:

Canada: *J. Macoun, 18, 51;* Lower St. Lawrence Valley, *J. Macoun, 5.*

Massachusetts: Cherry Brook, *E. A. Burt & A. B. Seymour;* Magnolia, *W. G. Farlow* (in Burt Herb. and Mo. Bot. Gard. Herb., 44066); Sharon, *A. P. D. Piguet*, comm. by W. G. Farlow, 11 (in Mo. Bot. Gard. Herb., 55590) and by Farlow Herb., 132 (in Mo. Bot. Gard. Herb., 59622); Wellesley, *L. W. Riddle, 11.*

New York: Ithaca, *G. F. Atkinson, 5089;* Karner, *H. D. House*, comm. by N. Y. State Mus. Herb. (in Mo. Bot. Gard. Herb., 54361, 55204); Westport, *C. H. Peck, 6*, type; White Plains, *W. H. Ballou, 1* (in Mo. Bot. Gard. Herb., 55030).

Michigan: Marquette, *C. J. Humphrey, 1870* (in Mo. Bot. Gard. Herb., 11089).
Wisconsin: Blue Mounds, *E. T. & S. A. Harper, 895.*
Washington: Bingen, *W. N. Suksdorf, 741, 907.*

69. P. heterocystidia Burt, n. sp.

Type: in Burt Herb.

Fructifications broadly effused, separable from the substratum when moistened, becoming cracked in drying and often loosening from substratum along the fissures, whitish when young, becoming light drab, cinnamon drab or vinaceous drab, the margin often paler; in section not colored or with only the hymenial layer clay-colored or brownish, 200–400 μ thick, 2-layered, the layer next to substratum usually broad, composed of loosely interwoven, somewhat ascending or longitudinally arranged, hyaline, nodose-septate hyphae 3–4½ μ in diameter, the hymenial layer 40–80 μ thick, composed of cystidia, gloeocystidia, and erect hyphae usually slightly colored near plane of origin from the under layer; cystidia consisting of both usual incrusted cystidia 25–35 × 6–8 μ, distributed in all parts of the outer layer, and of very large cystidia up to 40–100 × 20–50 μ which start from the base—often somewhat colored—of the hymenial layer; gloeocystidia slender, flexuous, 40–60 × 5–6 μ, between the basidia; basidia with 4 sterigmata; spores from spore collection white, even, cylindric, 12–15 × 3½–4½ μ.

Fructifications 2–7 cm. in diameter.

On fallen limbs of gray birch, beech, maple, *Carpinus, Magnolia,* and other frondose species. Canada to Mississippi and westward to Missouri and in Mexico. June to March. Common.

P. heterocystidia resembles *Corticium laeve* Pers. (=*C. evolvens* Fr.) in color but is a true *Peniophora,* readily distinguished from our other separable species by having incrusted cystidia of the usual size, other very large cystidia up to 20–50 μ in diameter, and gloeocystidia. Bresadola and von Höhnel & Litschauer confused this species with *P. carnea,* from which it differs in being much thicker, separable from the substratum when moistened, and being colored within on the hymenial side instead of next

to the substratum. Rarely a fructification may have the hymenium vary somewhat hydnaceous.

Specimens examined:

Exsiccati: Ellis, N. Am. Fungi, 716, under the name *Corticium glabrum*, 717a of some copies, under the name *Corticium subgiganteum*.

Canada: *J. Macoun, 3, 10, 14, 46.*

Ontario: Lake Rosseau, *E. T. & S. A. Harper, 755;* Ottawa, *J. Macoun, 110.*

Vermont: Middlebury, *E. A. Burt*, type, and 2 other gatherings.

Connecticut: Central Village, *J. L. Sheldon, 23*, comm. by N. Y. Bot. Gard. Herb.

New York: Bemis Heights, *C. H. Peck* (in N. Y. State Mus. Herb., under the name *Stereum albobadium*); Bronx Park, *Class in Mycology* (in N. Y. Bot. Gard. Herb., Mo. Bot. Gard. Herb., 61392, 61430, and Burt Herb.); Kirkland, *H. D. House* (in N. Y. State Mus. Herb., Mo. Bot. Gard. Herb., 59685, and Burt Herb.); Snyders, *C. H. Peck* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 56018); Syracuse, *L. M. Underwood*, in some copies of Ell. & Ev., Fungi Col., 221, under the name *Corticium glabrum;* White Plains, *W. H. Ballou* (in Mo. Bot. Gard. Herb., 55034).

New Jersey: Newfield, *J. B. Ellis.*

Pennsylvania: Meadville, *E. C. Smith*, comm. by L. O. Overholts, 8337 (in Mo. Bot. Gard. Herb., 59475); West Chester, *Everhart, Haines, Jefferis & Gray*, in Ellis, N. Am. Fungi, 716.

District of Columbia: Washington, *C. L. Shear, 1257a, 1260.*

Mississippi: Ocean Springs, *L. M. Underwood* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61484).

Ohio: Cincinnati, *C. G. Lloyd, 191, 2790, 4518;* Norwood, *C. G. Lloyd, 2274.*

Indiana: Millers, *E. T. & S. A. Harper, 962;* Union County, *M. F. & L. O. Overholts & B. Fink*, comm. by L. O. Overholts, 4204 (in Mo. Bot. Gard. Herb., 55636).

Illinois: Cypress, *C. J. Humphrey, 1347* (in Mo. Bot. Gard. Herb., 42923); Glencoe, *E. T. & S. A. Harper, 662, 646.*

Kentucky: Crittenden, *C. G. Lloyd* (in Lloyd Herb., 1411, and Mo. Bot. Gard. Herb., 55626).

Missouri: Columbia, *B. M. Duggar, 265, 288, 400, 472;* Pacific, *B. M. Duggar* (in Mo. Bot. Gard. Herb., 63417); near St. Louis, *E. A. Burt* (in Mo. Bot. Gard. Herb., 63418).
Mexico: Tepeite Valley near Guernavaca, *W. A. & E. L. Murrill, 400*, comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 54551).

70. P. borealis (Peck) Burt, n. sp.

Peniophora disciformis (DC) Cooke var. *borealis* Peck in Harriman Alaska Exped. **5**. The Fungi of Alaska, 43. 1904; Sacc. Syll. Fung. **17**: 175. 1905.

Type: in Mo. Bot. Gard. Herb.

Fructifications effused, thick, membranaceous, separable, becoming light buff in the herbarium, velvety with the numerous cystidia, the margin thinner, entire, clay-color, free in some places; in structure 60 μ thick, not colored, composed of hyaline hyphae 2 μ in diameter, not incrusted, densely and longitudinally arranged along the substratum and then curving obliquely outward to form the hymenial layer, and of occasional slender gloeocystidial organs with enlarged clavate or pyriform tips up to 4½–7 μ in diameter; cystidia incrusted, cylindric, 60–75 × 6–9 μ, confined to the hymenial surface but in great numbers there, protruding nearly their whole length beyond the basidia; a single detached spore is hyaline, even, 10 × 8 μ, but may be foreign.

Fructifications 5 mm.–2½ cm. long, 5 mm.–10 mm. wide.

On bark of small decaying twigs of a frondose species—perhaps *Alnus*. Alaska. June.

P. borealis has aspect somewhat suggestive of *P. aurantiaca* but is more buff-colored, with darker margin becoming free, and with cystidia so long and numerous as to be very conspicuous when viewed with a lens. The abundance of these cystidia is so great as to be a very important character in the recognition of this species by preliminary inspection.

Specimens examined:

Alaska: Aqua Dulce River, Yakutat Bay, *W. Trelease, 583*, type (in Mo. Bot. Gard. Herb., 5006).

71. P. lepida Bresadola, Mycologia **17**: 70. 1925.

Type: in Weir Herb.

Fructifications broadly effused, thick, waxy-membranaceous, separable from the substratum, somewhat horn-like and requiring moistening for a short time before sectioning, pinkish buff to light ochraceous-buff in the herbarium, somewhat pulverulent, the margin finally free and rolling up from the substratum; in section 500–600 μ thick, not colored, composed of densely arranged hyphae 3–3½ μ in diameter, which run longitudinally along the substratum and then curve obliquely into the hymenium; between the hyphae occur numerous slightly more deeply staining elongated organs of the nature of conducting organs or slender gloeocystidia; cystidia incrusted, cylindric, 6–8 μ in diameter, protruding up to 30 μ beyond the basidia, very numerous in the hymenial surface, the incrusted part about 20–45 μ long; no spores found.

Fructification 9 cm. long, 3½ cm. wide.

On a dead stub about 2½ cm. in diameter, of *Salix* sp. Idaho. June.

P. lepida has some resemblance to *P. gigantea* but is not quite as gelatinous in consistency as *P. gigantea* and occurs on *Salix*. The slender conducting hyphae or gloeocystidia should aid in recognizing the species. The broad layer of hyphae arranged longitudinally along the substratum and then curving outward into the hymenium is very like that of a resupinate *Stereum* but I recall no pileate *Stereum* of similar structure.

Specimens examined:

Idaho: National Forest, 50 miles east of Orofino, *A. S. Rhoads* (in Weir Herb., 16744, type).

72. P. Kauffmanii Burt, n. sp.

Type: in Mo. Bot. Gard. Herb., and probably in Kauffman Herb.

Fructifications long-effused, rather thin, adnate, small portions separable when moistened, between pale pinkish buff and tilleul-buff, not cracked, not waxy nor shining, the margin determinate, thinning out; in section 300–350 μ thick, 2-layered, with both layers of about equal thickness and the hymenial layer somewhat honey-yellow, the layer next to the substratum not colored, composed of loosely and longitudinally interwoven, thin-walled,

hyaline hyphae about 3 μ in diameter, of irregular outline; hymenial layer composed of densely arranged, erect hyphae, gloeocystidia, and cystidia; gloeocystidia flexuous, 45–100 × 4–7 μ; cystidia incrusted when wholly immersed, cylindric, obtuse, 30–45 × 6–8 μ, protruding 20–30 μ beyond the basidia in incrusted, or more usually, non-incrusted form, not abundant; spores hyaline, even, curved, 8–12 × 2½–3 μ, with pointed and tapering base, copious.

Fructifications 2–10 cm. long but broken off at one end, 1–2½ cm. wide.

On decaying limbs of *Fagus*. Kentucky. September. Probably local.

Among our few species of *Peniophora* which have gloeocystidia, *P. Kauffmanii* should be readily recognized by its occurrence on beech, buff color, structure of 2 equal layers, and small, incrusted cystidia.

Specimens examined:

Kentucky: Harlan, *C. H. Kauffman, 69,* type (in Mo. Bot. Gard. Herb., 22827).

73. P. alba Burt, n. sp.

Type: in Burt Herb.

Fructifications effused, very thin, somewhat membranaceous, small pieces separable when moistened, white, even, not shining, somewhat cracked by contraction in drying, the margin thinning out; in section 80–100 μ thick, not colored, with the hyphae loosely arranged near the substratum, suberect, branching, about 3 μ in diameter, not incrusted, only rarely nodose-septate; gloeocystidia curved, 30–45 × 3½–4½ μ, usually starting from the substratum; cystidia not incrusted or with some incrusting granules, thin-walled, 4–5 μ in diameter, protruding up to 30 μ beyond the basidia; spores hyaline, even, 4–5 × 2½ μ.

Fructifications fragmentary and not showing ends nor more than one side; such fragments 5 cm. long, 10–15 mm. wide.

On bark of dead cedar or spruce. Canada. September.

P. alba seems possible of recognition among our many whitish species of *Peniophora* by its pure white color, presence of gloeocystidia in addition to cystidia, and occurrence on coniferous bark.

Specimens examined:

Canada: locality not given, *J. Macoun, 57*, type.

74. P. tenella Burt, n. sp.

Type: in Mo. Bot. Gard. Herb. and Farlow Herb.

Fructifications effused, white, tender, thin, loosely attached, separable when moistened, velvety, setulose with the large cystidia, the margin indeterminate, thinning out; in section 150–200 μ thick, not colored, composed of a dense hymenial layer 75–90 μ thick, borne on a loosely interwoven layer composed of thin-walled, hyaline hyphae 3–4 μ in diameter, nodose-septate, sometimes granule-incrusted; hymenial layer composed of basidia, gloeocystidia, and incrusted cystidia; gloeocystidia numerous, flexuous, tapering from the base, 45–75 × 5–8 μ; cystidia very large, heavily incrusted, conical, 60–100 × 15–20 μ, wholly immersed, or protruding beyond the basidia up to 75 μ; spores copious, hyaline, even, 7½–9 × 3–4 μ.

Fructifications 1–2 cm. in diameter.

On coniferous bark. New Hampshire and Massachusetts. September and October. Rare.

P. tenella is distinguished from *P. pubera* by occurrence on coniferous, rather than frondose, substratum, by being so loosely attached to the substratum that small portions needed for sectioning may be separated from the substratum when moistened, and by the loosely interwoven hyphal layer equalling or exceeding in thickness the hymenial layer and containing no gloeocystidia nor cystidia.

Specimens examined:

New Hampshire: Chocorua, *W. G. Farlow*, type (in Mo. Bot. Gard. Herb., 7617).

Massachusetts: Cambridge, *A. P. D. Piguet*, comm. by W. G. Farlow, 30.

75. P. duplex Burt, n. sp.

Type: in Burt Herb.

Fructifications small, effused, thin, adnate, somewhat membranaceous, small pieces separable when moistened, becoming pale pinkish buff in the herbarium, even, not cracked, not shining, the

margin narrow, radiate-fibrillose; in section 100–200 μ thick, not colored, the hyphae with walls gelatinously modified, indistinct, about 3 μ in diameter, ascending, densely crowded together and interwoven and with numerous gloeocystidia present; gloeocystidia sometimes pyriform but usually more elongated, 20–45 × 6–9 μ, in all regions of the fructification; cystidia incrusted, cylindric, 25–30 × 4½–5 μ, protruding up to 20 μ beyond the basidia, confined to the hymenium; spores hyaline, even, flattened on one side, 5 × 2½ μ.

Fructifications received in fragments 1–2 cm. long, 5–10 mm. wide.

On bark of *Pinus austriaca* (cult.). New York. October.

In general aspect *P. duplex* suggests small fructifications of *P. gigantea* but not curling away from the substratum at all. The cystidia are smaller than those of *P. gigantea* and the latter does not have gloeocystidia.

Specimens examined:

New York: Shelter Island, *W. G. Farlow*, type.

76. P. mutata (Peck) Bresadola in Bourdot & Galzin, Soc. Myc. Fr. Bul. **28:** 399. 1913.

Corticium mutatum Peck, N. Y. State Mus. Rept. **43:** 67. 1890.

Type: in N. Y. State Mus. Herb.

Fructifications broadly effused, membranaceous, fleshy, thick, separable when moistened, drying white to pinkish buff, sometimes centrally tuberculose or with raduloid teeth and occasionally with radial folds, sometimes cracking in drying and showing the white, fibrillose subiculum in the fissures, the margin white, radially byssoid; in structure 300–1000 μ thick, composed of loosely arranged, ascending, thin-walled, hyaline hyphae 3–4 μ in diameter, occasionally nodose-septate; gloeocystidia pyriform, 15 × 7 μ, more or less numerous, sometimes grown out into elongated, flexuous form up to 100 × 4–5 μ, occurring as hyphal ends or branches in the sybhymenium; cystidia incrusted or not incrusted, 50–100 × 6–15 μ, sometimes not protruding beyond the basidia and sometimes so few present as to be found only after examination of several sections; basidia 4-spored, with short, thick, knob-like sterigmata; spores hyaline, even, cylindric, 8–16 × 3–4 μ.

Fructifications 3–7 cm. long, 1–3 cm. broad, sometimes larger by confluence.

Common on bark of decaying logs and fallen branches of *Populus* and also on *Tilia, Quercus, Acer,* and other frondose species. Canada to Alabama, westward to Idaho, in Europe and in Japan. July to November and in April.

P. mutata is a thick, somewhat fleshy, white, or whitish species occurring usually on bark of fallen poplar and basswood and showing in sectional preparations pyriform gloeocystidia, cystidia, and spores usually about $12 \times 3\frac{1}{2}$ µ. This species approaches the genus *Radulum* in thickness of the fructification, its obliquely ascending hyphae, and in occasional specimens having some raduloid teeth; such specimens have the aspect of *Radulum orbiculare* but differ from it by presence of the pyriform bodies and cystidia.

Specimens examined:

Exsiccati: Ellis, N. Am. Fungi, 717 a, under the name *Corticium subgiganteum,* 719, under the name *Corticium laeve;* Ell. & Ev., Fungi Col., 308, under the name *Corticium laeve.*

Austria: Langenschönbich, *F. v. H¨hnel,* comm. by V. Litschauer.

Canada: *J. Macoun, 7, 52;* Lower St. Lawrence Valley, *J. Macoun, 11, 81;* Ottawa, *J. Macoun, 40, 41,* and *136* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 55924); Ontario, Harraby, *E. T. & S. A. Harper, 685.*

Maine: Piscataquis County, *W. A. Murrill, 2451* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61402); Portage, *L. W. Riddle, 16.*

Vermont: Middlebury, *E. A. Burt,* two gatherings.

New York: Ithaca, *G. F. Atkinson, 22965;* Karner, *H. D. House, 14.153, 14.160* (in part), and two unnumbered specimens (in Mo. Bot. Gard. Herb., 44712, 44706, 54367, 55215); Sevey, *C. H. Peck,* type (in N. Y. State Mus. Herb.); Shokan, *C. H. Peck, T24* (in Mo. Bot. Gard Herb., 54660); Slingerlands, *C. H. Peck, T 23* (in Mo. Bot. Gard. Herb., 54659); Syracuse, *L. M. Underwood, 48* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61409, 61433); White Plains, *W. H. Ballou* (in Mo. Bot. Gard. Herb., 10458).

New Jersey: Newfield, *J. B. Ellis,* in Ellis, N. Am. Fungi, 717a, 719, and Ell. & Ev., Fungi Col., 308.

Florida: *W. W. Calkins.*

Alabama: Montgomery, *R. P. Burke, 13* (in Mo. Bot. Gard. Herb., 17193).

Ohio: Preston, *C. G. Lloyd, 1555;* West Elkton, *L. O. Overholts, 3164* (in Mo. Bot. Gard. Herb., 5712).

Indiana: Crawfordsville, *D. Reddick, 6, 8, 13, 14.*

Illinois: River Forest, *E. T. & S. A. Harper, 631.*

Michigan: Ann Arbor, *C. H. Kauffman.*

Wisconsin: Blue Mounds, *E. T. & S. A. Harper, 871.*

Minnesota: Princeton, *C. J. Humphrey, 899* (in Mo. Bot. Gard. Herb., 21044).

Missouri: Columbia, *B. M. Duggar, 561;* Meramec Highlands, *P. Spaulding* (in Mo. Bot. Gard. Herb., 63746); Pickering, *E. Bartholomew, 6425* (in Mo. Bot. Gard. Herb., 55195); St. Louis, *N. M. Glatfelter, 1377,* comm. by N. Y. Bot. Gard. Herb.; *E. A. Burt* (in Mo. Bot. Gard. Herb., 44073).

South Dakota: Custer, *J. R. Weir, 10019* (in Mo. Bot. Gard. Herb., 55799).

Idaho: Priest River, *J. R. Weir, 37;* St. Maries, *J. R. Weir, 560* (in Mo. Bot. Gard. Herb., 63179).

Japan: Bungo, *A. Yasuda, 107* (in Mo. Bot. Gard. Herb., 57024).

77. **P. Allescheri** Bresadola, Fungi Trid. **2:** 62. *pl. 172.* 1898; Sacc. Syll. Fung. **16:** 194. 1902.—But not as understood by Bourdot & Galzin and by Wakefield.

Kneiffia Allescheri Bresadola, Ann. Myc. **1:** 100. 1903.—*Gloeopeniophora Allescheri* (Bres.) v. Höhnel & Litschauer, K. Akad. Wiss. Wien Sitzungsber. **117:** 1082. 1908.

Type: in Bresadola Herb. and Burt Herb.

Fructifications broadly effused, membranaceous, fleshy, thick, drying white to pinkish buff, sometimes contracting in drying, curling away from the substratum more or less at the fissures and showing the white, fibrillose subiculum, the margin white, byssoid; in structure 300–1000 μ thick, composed of obliquely ascending and interwoven, hyaline hyphae more or less incrusted, 3–6 μ in diameter; gloeocystidia elongated, flexuous, 40–100 × 4–7 μ, often continued beyond the deeply staining portion as an

undifferentiated hypha, numerous in the subhymenium; cystidia incrusted or not incrusted, 30–60 × 6–10 μ; spores hyaline, even, 10–13 × 3–4 μ.

Fructifications 2–10 cm. long, 1–3 cm. broad.

On bark of fallen limbs of *Populus* and other frondose species. Canada to New York and westward to Washington, in West Indies, and in Europe.

The type of *P. Allescheri* and specimens of similar structure cited below differ so slightly from *P. mutata* that I have separated them from the latter only by all their gloeocystidia being of slender elongated form and perhaps specially differentiated middle portions of hyphae, while the gloeocystidia of *P. mutata* are terminal portions of hyphae and hyphal branches which are in many cases pyriform and in others afford indication by a pyriform base of having finally grown out from a pyriform body into an elongated gloeocystidium. It may be that when someone can keep under observation and examination a specimen of *P. mutata* during its season, he may find that pyriform gloeocystidia are present abundantly up to the time of copious spore production and then finally all become elongated so that the fructification would be referable to *P. Allescheri*. In this event *P. Allescheri* will become a synonym of *P. mutata* by priority of the latter.

While *P. mutata* has become correctly understood in Europe through my exchanges with Bresadola there is a misunderstanding there concerning *P. Allescheri*. Von Höhnel & Litschauer studied the original specimen of *P. Allescheri* in Bresadola Herb. and state, *loc. cit.*, that this consists of a mixture of fructifications of *P. cremea* and *P. Allescheri*, the latter as described by Bresadola and figured in his plate. The specimen shared with me by Bresadola is in such close agreement with the plate that the colored drawing of the upper figure may have been made from it, and it agrees also with the description. Its data as to collection is given "ad corticem Fagi silv. Bavaria. *Allescher*." The portions of the original specimens communicated to Bourdot & Galzin and to Miss Wakefield are apparently of the *P. cremea* component, referred to by v. Höhnel & Litschauer.

Specimens examined:

Sweden: *L. Romell, 439* (in Mo. Bot. Gard. Herb., 44305); Stockholm, *L. Romell, 102.*

Germany: Bavaria, *Allescher*, comm. by Bresadola, part of type.

Canada: Rideau Park, *J. Macoun, 325;* Ottawa, *J. Macoun, 133,* in part; Quebec, Ironsides, *J. Macoun, 256.*

New Hampshire: Jackson, *W. H. Snell, 624* (in Mo. Bot. Gard. Herb., 59246).

Vermont: Middlebury, *E. A. Burt.*

New York: Glasco, Ulster County, *P. Wilson, 40* (in Mo. Bot. Gard. Herb., 54747); Ithaca, *H. E. Stork, 6* (in Mo. Bot. Gard. Herb., 56643), *G. F. Atkinson, 8031, 22761, D. Reddick,* by Cornell Univ. Herb., 20567, *Van Hook,* Cornell Univ. Herb., 8011, and *Wright,* Cornell Univ. Herb., 8353.

Ohio: *C. G. Lloyd, 3920;* College Hill, *C. G. Lloyd, 3121* (in Lloyd Herb., Burt Herb., N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61419).

Indiana: Crawfordsville, *A. R. Bechtel, 10* (in Mo. Bot. Gard. Herb., 59648).

Michigan: Ann Arbor, *C. H. Kauffman, 12;* New Richmond, *C. H. Kauffman, 31* (in Mo. Bot. Gard. Herb., 9864).

British Columbia: Vancouver Island, *J. Macoun, 355* (in Mo. Bot. Gard. Herb., 55323).

Washington: Bingen, *W. N. Suksdorf, 702.*

West Indies: Grenada, Grand Etang, *R. Thaxter,* comm. by W. G. Farlow, 4.

78. P. subcremea v. Höhnel & Litschauer, K. Akad. Wiss. Wien Sitzungsber. **115:** 1600. *text f. 6.* 1906; Sacc. Syll. Fung. **21:** 408. 1912.

Type: type distribution in Rabenhorst, Fungi Eur., 3230, under the name *Corticium lacteum.*

Fructifications effused, thin, closely adnate, becoming cartridge-buff to ivory-yellow in the herbarium, not cracked, the margin thinning out; in section 40–150 μ thick, not colored, composed of suberect, bushy-branched hyphae 2–3 μ in diameter, not incrusted, only occasionally nodose-septate, and of flexuous gloeocystidia 40 × 4 μ, starting from the substratum in the type; cystidia not incrusted, 4½–6 μ in diameter, protruding up to

40 μ beyond the basidia; spores hyaline, cylindric, 3½–4½ × 2–2½ μ, copious.

Fructifications 1½–8 cm. long, 1½–5 cm. wide.

On bark and wood of *Pinus*. Finland, Montana, and Manitoba. September to November. Rare.

The specimen from Manitoba is on bark of a frondose species, but agrees well in other respects with the specimens on pine. The small spores are a distinguishing character of *P. subcremea.*

Specimens examined:

Exsiccati: Rabenhorst, Fungi Eur., 3230, type distribution, under the name *Corticium lacteum.*

Finland: Mustiala, *P. A. Karsten,* in Rabenhorst, Fungi Eur., 3230.

Montana: Anaconda, *E. E. Hubert,* comm. by J. R. Weir, 12010 (in Mo. Bot. Gard. Herb., 63370).

Manitoba: Winnipeg, *G. R. Bisby & I. L. Conners, 1183* (in Mo. Bot. Gard. Herb., 59047).

79. **P. admirabilis** Burt, n. sp.

Type: in Burt Herb.

Fructifications broadly effused, adnate, thin, membranaceous, small pieces separable, becoming cartridge-buff in the herbarium, fibrillose, not shining, even, with but few small cracks, the margin thinning out, with its hyphae loosely interwoven; in section 180–240 μ thick, not colored, composed of suberect, thin-walled hyphae 3½–4 μ in diameter, not incrusted, of gloeocystidia both elongated and vesicular, and of large chlamydospores; cystidia cylindric, incrusted, up to 105 × 9 μ, confined to the hymenium, somewhat disorganized by potassium hydrate solution; vesicular gloeocystidia and vesicular spaces up to 45 × 30 μ; chlamydospores as seen singly on hyphal branches are up to 15 × 9 μ; basidiospores white in spore collection, even, 6–7 × 3 μ, borne 4 to a basidium.

Fructifications 3–10 cm. long, 1–2 cm. wide.

On decaying wood of stump of *Ulmus*. New York. May.

P. admirabilis is well marked among our species which have gloeocystidia by the presence of large imbedded spores.

Specimens examined:
New York: Oneonta, *E. A. Burt.*

80. P. versata Burt, n. sp.
Type: in Burt Herb.
Fructifications effused, thin, membranaceous, small pieces separable when moistened, becoming pinkish buff in the herbarium, not waxy, the margin thinning out, fibrillose; in section 150–300 μ thick, not colored, composed of suberect, interwoven hyphae about 3 μ in diameter, with walls somewhat gelatinously modified, and of gloeocystidia; gloeocystidia numerous, flexuous, 35–55 × 6–8 μ; cystidia not incrusted, tapering towards the apex, 6 μ in diameter, protruding up to 40 μ, scarcely or perhaps not at all distinguishable from gloeocystidia; basidia with 4 sterigmata; spores hyaline, even, 4–5 × 2½–3 μ.
Fructifications 2–5 mm. long, 5–15 mm. wide.
On slightly decayed red fir planks and cross-ties. Washington. September and October.
The fructifications of *P. versata* stand out conspicuously against the blackened timber upon which they occur. The resemblance of the protruding cystidia to gloeocystidia and the possibility that they have the function of gloeocystidia or may be gloeocystidia functioning as cystidia should enable this species to be readily distinguished from species containing cystidia and gloeocystidia quite distinct from each other.
Specimens examined:
Washington: Chehalis, *C. J. Humphrey, 6285;* Edmonds, *C. J. Humphrey, 7623*, type.

81. P. albo-straminea Bresadola, Mycologia **17**: 69. 1925.
Type: in Weir Herb.
Fructifications orbicular, finally confluent and broadly effused, thin, very tender, small pieces separable when moistened, becoming between cartridge-buff and ivory-yellow in the herbarium, somewhat cracked, even, the margin pruinate; in section 60–90 μ thick, not colored, composed of somewhat loosely arranged hyphae 3–5 μ in diameter, occasionally nodose-septate, and of gloeocystidia; gloeocystidia flexuous to zigzag, 40–60 × 4½–6 μ,

usually starting from the substratum and wholly immersed, sometimes protruding beyond the basidia; cystidia, if really distinct from gloeocystidia, not incrusted, 4½–8 μ in diameter, protruding up to 30 μ beyond the basidia; spores hyaline, even, 5–7½ × 3–4 μ.

Fructifications 2–8 cm. long, 1½–3 cm. wide.

On wood and bark of decaying *Alnus tenuifolia* and *Quercus californica*. Idaho and California. October.

The gloeocystidia, sometimes of zigzag form, and cystidia, which are possibly only protruding portions of gloeocystidia, are marked characters of the type specimen which should afford recognition of *P. albo-straminea* if these are constant specific characters. However, the buff color, *Alnus* substratum, and presence of gloeocystidia should suffice. In No. 17069 a foreign mycelium of coarse hyphae is underneath the fructification proper.

Specimens examined:

Idaho: Priest River, *J. R. Weir, 17069*, type, and *16818* (both in Weir Herb.).

California: Massack, Plumas National Forest, *A. S. Rhoads, 17* (in Mo. Bot. Gard. Herb., 56986).

82. P. Taxodii Burt, n. sp.

Type: in Burt Herb.

Fructifications effused, very thin, closely adnate, whitish to pale olive-buff in the herbarium, the hymenium loose and rather hypochnoid under a lens, the margin indeterminate, thinning out; in section 45–60 μ thick, not colored, composed of erect, branching hyphae 2–2½ μ in diameter, not incrusted, not nodose-septate, and of numerous cystidia, gloeocystidia, and crystalline matter; cystidia not incrusted, thin-walled, tapering to a sharp apex, 6–8 μ in diameter, protruding 20–40 μ beyond the basidia, often starting from the substratum; gloeocystidia often not distinguishable from the cystidia except by granular, deeply staining contents, protruding up to 20–40 μ beyond the basidia; spores hyaline, even, 7–7½ × 3–3½ μ.

Fructification 7 cm. long, 1½–2 cm. wide.

On decorticated top limb of prostrate top of *Taxodium dis-*

tichum left in the swampy woods. Texas. September. Probably local.

P. Taxodii has thin grayish fructifications on the blackened, weathered wood of a prostrate tree top left in lumbering operations. It is difficult to distinguish cystidia from gloeocystidia in the sections unless the organs lacking contents which take the stain are cystidia and the deep-staining and more numerous bodies gloeocystidia, for both start from the substratum, protrude beyond the hymenium, and taper to a sharp point.

Specimens examined:

Texas: Beaumont, *C. J. Humphrey, 5947*, type.

83. P. investiens Burt, n. sp.

Type: in N. Y. Bot. Gard. Herb., Mo. Bot. Gard. Herb., and Burt Herb.

Fructifications longitudinally effused, thin, adnate, small pieces separable when moistened, becoming cartridge-buff in the herbarium, even, not cracked, not shining, the margin thinning out, minutely tomentose; in section 180 μ thick, not colored, with a broad layer of densely interwoven hyphae 2½–3 μ in diameter, thin-walled, not incrusted, not nodose-septate; gloeocystidia flexuous, 25–40 × 4–5 μ, immersed in the hymenium; cystidia not incrusted, 9 μ in diameter, protruding up to 60 μ beyond the basidia; basidia with 4 prominent sterigmata; spores hyaline, even, 12–13 × 3–3½ μ—one spore seen is 15 × 6 μ but perhaps does not belong.

Fructifications 8 cm. long, 1 cm. wide.

On decaying stem of palmetto. Bermuda. December.

The presence of the gloeocystidia in the hymenial layer and not also in the interwoven hyphae near the trama, together with the long spores and occurrence on palmetto, should enable the recognition of *P. investiens*.

Specimens examined:

Bermuda: *Stewardson Brown, N. L. Britton & F. J. Seaver, 1324*, type (in N. Y. Bot. Gard. Herb., Mo. Bot. Gard. Herb., 63730, and Burt Herb.).

84. P. incarnata (Pers.) Karsten, Hedwigia **1889**: 27. F. 1889; Finska Vet.-Soc. Bidrag Natur och Folk **48**: 424. 1889;

Massee, Linn. Soc. Bot. Jour. **25**: 147. Jl. 1889; Sacc. Syll. Fung. **9**: 241. 1891; Bourdot & Galzin, Soc. Myc. Fr. Bul. **28**: 404. 1913; Rea, Brit. Basid. 694. 1922.

Thelephora incarnata Persoon, Syn. Fung. 573. 1801; Myc. Eur. **1**: 130. 1822 (Corticium); Fries, Syst. Myc. **1**: 444. 1821; Elenchus Fung. **1**: 219. 1828.—*Corticium incarnatum* (Pers.) Fries, Epicr. 564. 1838; Hym. Eur. 654. 1874; Berkeley, Brit. Fung. 275. 1860; Berk. & Curtis, Grevillea **2**: 4. 1873; Peck, N. Y. State Mus. Rept. **24**: 80. 1872; Morgan, Cincinnati Soc. Nat. Hist. Jour. **10**: 201. 1888; Sacc. Syll. Fung. **6**: 625. 1888.—*Kneiffia incarnata* (Pers.) Bresadola, Ann. Myc. **1**: 103. 1903.—*Gloeopeniophora incarnata* (Pers.) v. Höhnel & Litschauer, K. Akad. Wiss. Wien Sitzungsber. **116**: 816. 1907.—*Peniophora aemulans* Karsten, Finska Vet-Soc. Bidrag Natur och Folk **48**: 425. 1889; Sacc. Syll. Fung. **9**: 239. 1891.

Fructifications effused, closely adnate, drying pinkish cinnamon to warm buff, cracking, the margin sometimes paler, thinning out; in section 100–250 μ thick, not colored, composed of hyaline, thin-walled hyphae 2–3 μ in diameter, densely interwoven along the substratum and then becoming suberect and extending between more or less numerous gloeocystidia and some cystidia; gloeocystidia sometimes broadly ovoid, 30–45 × 10–15 μ, usually more cylindric and narrower, 30–60 × 6–10 μ; cystidia becoming incrusted, 30–45 × 6–10 μ, rarely protruding beyond the basidia; basidia with 4 sterigmata; spores hyaline, even, cylindric, flattened on one side, 6–10 × 3–4½ μ.

Fructifications 2–10 cm. long, 1–2 cm. broad, sometimes in scattered, small, tubercular growths 2–5 mm. in diameter on lenticels of small limbs.

On wood and bark of fallen limbs of frondose species usually. Europe, Canada to Alabama, and westward to the Pacific states, and in Japan. Throughout the year. Common.

P. incarnata is recognizable by its closely adnate, reddish fructifications, spores 6–9 × 3–4 μ, and abundant gloeocystidia. Sometimes one has to search several sections before finding an incrusted cystidium. The spores run slightly smaller in most American gatherings than in the fewer European specimens which I have seen and are with us usually only about 6–8 × 3 μ.

Specimens examined:

Exsiccati: Cooke, Fungi Brit., 7; Reliq. Farlowianae, 342; Ravenel, Fungi Am., 140; Romell, Fungi Scand., 33.

Sweden: Stockholm, *L. Romell, 67, 100, 101,* and in Romell, Fungi Scand., 33.

Finland: Mustiala, *P. A. Karsten,* authentic specimen of *P. aemulans.*

Austria: Tirol, *V. Litschauer,* four specimens.

Italy: locality not given, *G. Bresadola,* two specimens.

England: Knys Lynn, *C. B. Plowright,* in Cooke, Fungi Brit., 7; Yorkshire, *E. M. Wakefield* (in Mo. Bot. Gard. Herb., 57124).

Newfoundland: Bay of Islands, *A. C. Waghorne, 5, 165* (in Mo. Bot. Gard. Herb., 43987, 5010).

Ontario: Harraby, Lake Rosseau, *E. T. & S. A. Harper, 791.*

Maine: Piscataquis County, *W. A. Murrill, 1861* (in N. Y. Bot. Gard. Herb., Burt Herb., and Mo. Bot. Gard. Herb., 61591); Orono, *P. L. Ricker, 621.*

New Hampshire: Chocorua, *W. G. Farlow, c39* (in Mo. Bot. Gard. Herb., 43974), and in Reliq. Farlowianae, 342.

Vermont: Middlebury, *E. A. Burt,* six gatherings; Ripton, *E. A. Burt,* two gatherings.

Massachusetts: *W. G. Farlow, 4;* Sharon, *A. P. D. Piguet, 5,* two unnumbered specimens, comm. by W. G. Farlow (in Mo. Bot. Gard. Herb., 55220, 55446, 55600).

New York: Albany, *H. D. House,* six gatherings (in Mo. Bot. Gard. Herb., 57412, 57457, 57519, 59684, 59700, 63448); Alcove, *C. L. Shear, 246;* Fulton, *A. E. Fivaz,* comm. by A. H. W. Povah, 136 (in Mo. Bot. Gard. Herb., 58158); Ithaca, *G. F. Atkinson, 3034, C. J. Humphrey, C. O. Smith,* comm. by G. F. Atkinson, 8225, *Van Hook,* comm. by G. F. Atkinson, 8066, *H. H. Whetzel,* Plant Path. Herb., 12228 (in Mo. Bot. Gard. Herb., 60599); Orient, *R. Latham, 144* (in Mo. Bot. Gard. Herb., 44230); Orient Point, *R. Latham,* comm. by N. Y. State Mus. Herb. (in Mo. Bot. Gard. Herb., 55815, 55922); Syracuse, *L. M. Underwood, 2, 89* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61567, 61598); Vaughns, *S. H. Burnham, 14* (in Mo. Bot. Gard. Herb., 54500).

Pennsylvania: Center Hall, *E. West,* comm. by L. O. Overholts,

3661 (in Mo. Bot. Gard. Herb., 54702); State College, *L. O. Overholts, 4807* (in Mo. Bot. Gard. Herb., 56340); Trexlertown, *W. Herbst, 23,* and comm. by Lloyd Herb., 3611.

Maryland: Takoma Park, *C. L. Shear, 1337.*

District of Columbia: Washington, *C. L. Shear, 1257, 1267.*

West Virginia: Paw Paw, *C. L. Shear, 1174.*

South Carolina: Aiken, *H. W. Ravenel,* in Ravenel, Fungi Am., 140.

Florida: Royal Palm Hammock, *W. A. Murrill, 123, 136,* comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 62098, 62099).

Alabama: Auburn, *F. S. Earle, 2299* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61416); Montgomery County, *R. P. Burke, 19, 275, 630, 664, 666, 679, 699* (in Mo. Bot. Gard. Herb., 16700, 57158, 63099, 63076, 63101, 63097, 63103).

Kentucky: *C. G. Lloyd, 1878.*

Ohio: College Hill, *Aiken,* comm. by C. G. Lloyd, 2327.

Wisconsin: Madison, *W. Trelease* (in Mo. Bot. Gard. Herb., 44314); Palmyra, *A. O. Stucki, 39.*

Iowa: Woodbine, *C. J. Humphrey & C. W. Edgerton,* comm. by C. J. Humphrey, 6566 (in Mo. Bot. Gard. Herb., 20691).

Missouri: Bismarck, *L. O. Overholts* (in Mo. Bot. Gard. Herb., 63454); Perryville, *L. O. Overholts, 2687* (in Mo. Bot. Gard. Herb., 44287).

Kansas: Phillips County, *E. Bartholomew;* Rooks County, *E. Bartholomew, 2046* (in Mo. Bot. Gard. Herb., 4842, 44313).

Colorado: Mancos, *G. G. Hedgcock,* comm. by C. J. Humphrey, 2551 (in Mo. Bot. Gard. Herb., 9783).

New Mexico: Tyom Experiment Station, *W. H. Long, 21564* (in Mo. Bot. Gard. Herb., 55142).

Alaska: Farragut Bay, *W. Trelease, 582* (in Mo. Bot. Gard. Herb., 4852).

Washington: Bingen, *W. N. Suksdorf, 715, 745, 760, 765, 881, 882, 904.*

Japan: Prov. Bungo, *A. Yasuda, 119, 123* (in Mo. Bot. Gard. Herb., 59470, 59474).

85. P. aurantiaca Bresadola in Bourdot & Galzin, Soc. Myc. Fr. Bul. **28**: 402. 1913; Rea, Brit. Basid. 694. 1922.

Corticium aurantiacum Bresadola, Fungi Trid. **2**: 37. *pl. 144, f. 2.* 1892; Sacc. Syll. Fung. **11**: 126. 1895.—*Kneiffia aurantiaca* Bresadola, Ann. Myc. **1**: 103. 1903.—*Gloeopeniophora aurantiaca* (Bres.) v. Höhnel & Litschauer, K. Akad. Wiss. Wien Sitzungsber. **117**: 1094. 1908.

Type: probably in Bresadola Herb.; authentic specimen in Burt Herb.

Fructifications effused, beginning as small, convex outgrowths at lenticels of the bark, spreading so as to form circular patches which become confluent, adnate, bright orange-pink to orange-chrome, fading in the herbarium to light pinkish cinnamon and light buff, the margin white at first, radiating; in section not colored, 150–250 μ thick, with the hyphae densely and longitudinally arranged in a rather broad layer next to the substratum except at the points of emergence from the lenticels, hyaline, thin-walled, 3–4 μ in diameter; gloeocystidia 30–60 × 6–9 μ, abundant in the convex portions; cystidia rough-walled, pointed, up to 45 × 8 μ, sometimes protruding 30 μ beyond the basidia, more often wholly immersed and 30 × 4–5 μ; basidia large, 60 × 10–12 μ, often protruding beyond the immature basidia when fruiting and bearing 4 sterigmata; spores hyaline, even, 12–16 × 6–12 μ.

Fructifications 1–5 mm. in diameter at first, then laterally confluent over areas 1–10 cm. long, ½–2 cm. broad.

On dead *Alnus* of various species. Labrador to North Carolina, westward to northern United States and Canada to British Columbia and Oregon, and in Europe. August to November. Common.

P. aurantiaca is easily recognized by its occurrence on dead twigs of alder, in bright incarnate or orange-red fructifications with large spores up to 15 × 10 μ. These spores are usually borne copiously and show well in crushed preparations. To demonstrate the gloeocystidia and cystidia it is necessary to examine sections cut through the convex or papilliform points of origin of the fructifications. Sometimes examination of many sections is necessary for demonstration of the cystidia. Failure to cut the sections from places above stated led me to refer gatherings of this species to *Corticium laetum* for some of my cor-

respondents. *C. laetum* may occur on *Alnus* and has color and spores like *P. aurantiaca.*

Specimens examined:

Exsiccati: de Thümen, Myc. Univ., 112, under the name *Corticium incarnatum;* Linhart, Fungi Hung., 438, under the name *Peniophora incarnata.*

Sweden: *L. Romell, 62.*

Austria: Tirol, *V. Litschauer,* three specimens, *E. Rehm,* in Myc. Univ., 112.

Hungary: Petrozsény, *G. Linhart,* in Linhart, Fungi Hung., 438.

Italy: Trient Alps, *G. Bresadola,* authentic specimen.

England: Lyndhurst, Hamp., *E. M. Wakefield* (in Mo. Bot. Gard. Herb., 57127).

Labrador: The Strait, *A. C. Waghorne, 5* (in Mo. Bot. Gard. Herb., 43986).

Newfoundland: Bay of Islands, *A. C. Waghorne, 341* (in Mo. Bot. Gard. Herb., 5012).

New Brunswick: Campobello, *W. G. Farlow, 1.*

Canada: *J. Macoun, 17, 116;* Carleton's Place, *J. Macoun, 158;* Ottawa, *J. Macoun, 25.*

Maine: Costigan, *W. A. Murrill, 1766* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61407); Kittery Point, *R. Thaxter & E. A. Burt;* Portage, *L. W. Riddle, 13;* Westbrook, *P. L. Ricker, 977.*

New Hampshire: Chocorua, *W. G. Farlow, c6* (in Mo. Bot. Gard. Herb., 44124); Hanover, *G. R. Lyman, 24* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61587).

Massachusetts: Weston, *A. B. Seymour, T34* (in Mo. Bot. Gard. Herb., 15759).

New York: Childwold, *G. F. Atkinson & B. M. Duggar,* Cornell Univ. Bot. Dept. 5056; Hudson Falls, *S. H. Burnham, 28* (in Mo. Bot. Gard. Herb., 54491); Karner, *H. D. House, 14.164* and another specimen, comm. by N. Y. State Mus. Herb. (in Mo. Bot. Gard. Herb., 44713, 54372).

Pennsylvania: Bear Meadows, *L. O. Overholts, 2677* (in Mo. Bot. Gard. Herb., 20277).

North Carolina: Chapel Hill, *W. C. Coker, 4705* (in Mo. Bot. Gard. Herb., 57425).

Michigan: Gogebic County, *E. A. Bessey, 184* (in Mo. Bot. Gard. Herb., 56581); Vermilion, *A. H. W. Povah* (in Mo. Bot. Gard. Herb., 18274).

Montana: Evaro, *J. R. Weir, 410* (in Mo. Bot. Gard. Herb., 21617); Missoula, *J. R. Weir, 349, 425* (in Mo. Bot. Gard. Herb., 6105, 14765).

Idaho: Addie, *J. R. Weir, 12005* (in Mo. Bot. Gard. Herb., 63321).

Manitoba: Norway House, *G. R. Bisby, 1460* (in Mo. Bot. Gard. Herb., 61642).

British Columbia: *J. Macoun, 752*, comm. by J. Dearness (in Mo. Bot. Gard. Herb., 12027); Agassiz, *J. R. Weir, 359* (in Mo. Bot. Gard. Herb., 16760); Salmo, *J. R. Weir, 515* (in Mo. Bot. Gard. Herb., 14170); Sidney, *J. Macoun, 1, 72, 752* (in Mo. Bot. Gard. Herb., 5755, 55339, 55318).

Washington: Kalama, *C. J. Humphrey, 6134;* Olympia, *C. J. Humphrey, 6304;* Seattle, *W. A. Murrill, 141*, and an unnumbered specimen, comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 55731, 55733).

Oregon: Corvallis, *S. M. Zeller, 1906* (in Mo. Bot. Gard. Herb., 56882).

86. P. pubera (Fr.) Sacc. Syll. Fung. **6**: 646. 1888; Massee, Linn. Soc. Bot. Jour. **25**: 149. 1889; Bourdot & Galzin, Soc. Myc. Fr. Bul. **28**: 400. 1913; Rea, Brit. Basid. 693. 1922.

Thelephora pubera Fries, Elenchus Fung. **1**: 215. 1828.—*Corticium puberum* Fries, Epicr. 562. 1838; Hym. Eur. 652. 1874; Patouillard, Tab. Anal. Fung. **1**: 66. *f. 152.* 1883; Bresadola, Fungi Trid. **2**: 38. *pl. 145. f. 1.* 1892.—*P. pubera* forma *villosa* Bresadola, I. R. Accad. Agiati Atti **3**: 113. 1897.—*Kneiffia pubera* (Fr.) var. *villosa* Bresadola, Ann. Myc. **1**: 101. 1903.

Fructifications effused, closely adnate, white, becoming dirty whitish to light buff and pinkish buff in the herbarium, and widely cracked, the hymenium even, setulose with the large cystidia, the margin indeterminate, thinning out; in section 45–400 μ thick, not colored, composed of rather crowded, erect hyphae 2–4 μ in diameter, thin-walled, not incrusted, and of gloeocystidia and incrusted cystidia; gloeocystidia flexuous, 30–60 × 4½–9 μ;

cystidia incrusted, conical, pointed, fusiform, 50–90 × 8–20 μ, wholly immersed or protruding up to 50 μ; spores hyaline, even, depressed on one side.

Fructifications 2–6 cm. long, 1–3 cm. wide.

On decaying wood, logs and limbs of frondose species, rarely on conifers. In Europe and from Canada to Louisiana and westward to British Columbia and Oregon. May to January. Common.

P. pubera is characterized by having gloeocystidia, large, conical, heavily incrusted cystidia, and spores usually 7–9 × 3½–4 μ. The gloeocystidia show well in my permanent mounts in glycerine, after the sections have been stained with eosin and stood for a few hours in glycerine. I did not find an authentic specimen of *P. pubera* in Kew or Fries Herbaria but specimens received under this name from Bresadola, Litschauer, Romell, and Miss Wakefield have gloeocystidia in every specimen and other characters as stated and show agreement in the European concept of this species. Specimens with the other characters of *P. pubera* but lacking gloeocystidia should be compared with *P. guttulifera*. In North America, *P. pubera* forms thinner fructifications than in Europe and is sometimes paler, drying rarely whitish or with a slight yellowish tint.

Specimens examined:

Sweden: Göteborg, *L. Romell, 174*.

Germany: Westphalia, Lengerich, *W. Brinkmann*, authentic specimen of *P. pubera* Fr. f. *villosa* from Bresadola.

Austria: Tirol, Innsbruck, *V. Litschauer*, two specimens; Stubai, *V. Litschauer*.

Italy: Trient, *G. Bresadola*.

Great Britain: S. Wales, Swansea, *E. M. Wakefield* (in Mo. Bot. Gard. Herb., 57123).

Canada: Quebec, Hull, *J. Macoun, 388*.

New Hampshire: Chocorua, *W. G. Farlow, 6, 6b, 27,* and *29* (in Burt Herb.), and an unnumbered specimen and *152* (in Mo. Bot. Gard. Herb., 7843, 55244).

Massachusetts: Magnolia, *W. G. Farlow*, two specimens.

Rhode Island: Woonsocket, *W. H. Snell, 7M, 8M* (in Mo. Bot. Gard. Herb., 56805, 56806).

New York: Ithaca, *G. F. Atkinson, 8227, 14363,* and *C. Thom,* comm. by G. F. Atkinson, 14372; Karner, *H. D. House, 14.165* in part (in Mo. Bot. Gard. Herb., 44715).

New Jersey: Newfield, *J. B. Ellis,* three specimens (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61401, 61443, 63467).

Maryland: Takoma Park, *C. L. Shear, 1129, 1158.*

District of Columbia: Takoma Park, *C. L. Shear, 964.*

Virginia: Crabbottom, *W. A. Murrill* (in N. Y. Bot. Gard. Herb.).

Florida: *W. W. Calkins, 860* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61455).

Alabama: Montgomery County, *R. P. Burke, 207, 208, 277, 347, 375, 376, 377, 424, 460, 468, 658, 662, 806, 807* (in Mo. Bot. Gard. Herb., 57080, 57081, 57159, 57218, 57245, 57244, 57243, 57261, 57282, 57287, 63085, 63087, 63109, and 63110 respectively).

Louisiana: St. Martinville, *A. B. Langlois, 2685, cl.*

Kentucky: Harlan, *C. H. Kauffman, 66* (in Mo. Bot. Gard. Herb., 16346).

Wisconsin: Blue Mounds, *Miss A. C. Stucki, 38;* Madison, *C. J. Humphrey, 2488* (in Mo. Bot. Gard. Herb., 11277).

Missouri: Creve Coeur Lake, *L. O. Overholts, 3166, 661* (in Mo. Bot. Gard. Herb., 5708, 5710).

Montana: Anaconda, Mt. Hagan, *J. R. Weir, 11253* (in Mo. Bot. Gard. Herb., 63256).

Idaho: Coolin, *J. R. Weir, 11505, 11516* (in Mo. Bot. Gard. Herb., 63286, 63289).

Manitoba: Winnipeg, *G. R. Bisby, 1345* (in Mo. Bot. Gard. Herb., 60555).

British Columbia: Cormac, *J. Macoun, 658* (in Mo. Bot. Gard. Herb., 55328); Sidney, *J. Macoun, 788* (in Mo. Bot. Gard. Herb., 55329); Vancouver Island, Oak Bay, *J. Macoun, 600* (in Mo. Bot. Gard. Herb., 55327); Victoria, *J. Macoun, 564* (in Mo. Bot. Gard. Herb., 55326).

Washington: Chehalis, *C. J. Humphrey, 6277.*

Oregon: Corvallis, *S. M. Zeller, 1851, 1855, 1904* (in Mo. Bot. Gard. Herb., 56863, 56864, 56880).

87. P. pertenuis (Karsten) Burt, n. comb.

Corticium pertenue Karsten, Hedwigia **29**: 270. 1890; Finska

Vet.-Soc. Bidrag Natur och Folk **51**: 226. 1892; Sacc. Syll. Fung. **9**: 234. 1891; v. Höhnel & Litschauer, K. Akad. Wiss. Wien Sitzungsber. **115**: 1556. 1906—(In part) *Gloeocystidium praetermissum* (Karst.) v. Höhnel & Litschauer, K. Akad. Wiss. Wien Sitzungsber. **115**: 1565. 1906.—An *Peniophora praetermissa* Karsten, Finska Vet.-Soc. Bidrag Natur och Folk **48**: 423. 1889?

Type: probably in Karsten Herb. and fragment in Burt Herb.

Fructifications long-effused, closely adnate, not separable when moist, very thin, waxy, even, white or whitish, drying pale pinkish buff to cream color, the margin thinning out; in section 60–150 μ thick, not colored, with the hyphae 3–4 μ in diameter, erect, branching, not incrusted, bearing the compact hymenium; gloeocystidia numerous, variable in form, often tapering, 20–60 × 6–8 μ; cystidia hair-like, not incrusted, 4–5 μ in diameter, protruding up to 20 μ beyond the basidia, few and scattered; spores copious, hyaline, even, curved, 7–10 × 4–5 μ.

Fructifications 2–10 cm. long, 1–2 cm. wide.

On decaying coniferous wood. In Europe, in Canada to District of Columbia, and in Oregon, Jamaica and Bermuda. July to November. Rare in North America.

The principal characteristics of *P. pertenuis* aiding in its recognition are occurrence in thin, whitish, waxy fructifications on old decaying coniferous wood, presence of gloeocystidia, and hair-like non-incrusted cystidia which are not destroyed in any degree by the treatment of the sections with potassium hydrate solution, and the curved spores. *P. tenuis* differs in having its cystidia incrusted at the tip. I have not seen an authentic specimen of *P. praetermissa* but the specimen sent to me under this name by Bresadola and one of the two specimens from Litschauer have their cystidia almost completely disintegrated by the potassium hydrate treatment in clearing and swelling the tissues of sections, as occurs also in *P. glebulosa*. Hence, I think that *P. praetermissa* may eventually be regarded by European mycologists as specifically distinct from *P. pertenuis*.

Specimens examined:

Finland: Mustiala, *P. A. Karsten*, portion of type, comm. by Bresadola, also authentic specimen on *Picea* from Karsten.

Sweden: Stockholm, *L. Romell, 116, 138, 162, 163, 164, 183, 191, 193, 203, 212, 215.*

Austria: Natters, Tirol, *V. Litschauer*, under the name *Gloeocystidium praetermissum.*

Canada: Ottawa, *J. Macoun, 42, 313;* St. Lawrence Valley, *J. Macoun, 41.*

New Hampshire: Chocorua, *W. G. Farlow, 5.*

New Jersey: Newfield, *J. B. Ellis* (in N. Y. Bot. Gard. Herb. and Mo. Bot. Gard. Herb.).

District of Columbia: Washington, *C. J. Humphrey, 2525* (in Mo. Bot. Gard. Herb., 20383).

Montana: Trego, *J. R. Weir, 11969* (in Mo. Bot. Gard. Herb., 63227).

Idaho: Coolin, *J. R. Weir, 11512* (in Mo. Bot. Gard. Herb., 63287); Priest River, *J. R. Weir, 139* (in Mo. Bot. Gard. Herb., 63468).

Oregon: Portland, *C. J. Humphrey, 6127.*

Washington: Falcon Valley, *W. N. Suksdorf, 724.*

Bermuda: Paget Marsh, on *Sabal, H. H. Whetzel, Ao, Abd* (in Mo. Bot. Gard. Herb., 58719, 58906).

Jamaica: Troy and Tyre, *W. A. Murrill & W. Harris, 1053,* in part, comm. by N. Y. Bot. Gard. Herb.

88. P. tenuis (Pat.) Massee, Linn. Soc. Bot. Jour. **25:** 149. 1889.

Corticium tenue Patouillard, Rev. Myc. **7:** 152. 1885; Tab. Anal. Fung. **1:** 203. *f. 462.* 1886; Sacc. Syll. Fung. **6:** 632. 1889.—*Kneiffia tenuis* (Pat.) Bresadola, Ann. Myc. **1:** 105. 1903. —*Gloeocystidium tenue* (Pat.) v. Höhnel & Litschauer, Wiesner Festschr. Wien, 70. 1908; Bourdot & Galzin, Soc. Myc. Fr. Bul. **28:** 364. 1913.

Fructifications effused, closely adnate, thin, white, drying whitish to pale pinkish buff, somewhat pruinose, the margin thinning out; in section 60–180 μ thick, not colored, with the hyphae erect, branching, 3–4 μ in diameter, thin-walled, not incrusted; gloeocystidia 20–60 × 6–8 μ, flexuous; cystidia hair-like, cylindric, 4–6 μ in diameter, protruding 20–45 μ beyond the basidia, incrusted about the tip; spores hyaline, even, curved, 8–10 × 4–4½ μ.

Fructifications 2–6 cm. long, 1–2 cm. wide.

On decaying wood and bark of frondose species more usually. Europe and Massachusetts. July to December. Rare.

P. tenuis is doubtfully distinct from *P. pertenuis*, having the same aspect and microscopical characters except that some of the cystidia have incrusting granules at the tips, as shown in the figures by Patouillard cited above.

Specimens examined:

Germany: Westphalia, Lengerich, *W. Brinkmann*, comm. by Bresadola.

Austria: Tirol, *V. Litschauer*.

France: Allier, St. Priest, *H. Bourdot, 6530;* Aveyron, *A. Galzin, 11689,* comm. by H. Bourdot, 18554.

Massachusetts: Brookline, Hammond's Pond, *G. R. Lyman, 183.*

89. P. serialis (Bres.) v. Höhnel & Litschauer, K. Akad. Wiss. Wien Sitzungsber. **116:** 777. 1907.

Kneiffia serialis Bresadola, Ann. Myc. **1:** 101. 1903 (in part); Sydow, Myc. Germ., 1. 1903.—Not *Xerocarpus Cacao* Karsten, Hedwigia **29:** 271. 1890.—An *Corticium seriale* Fries, Epicr. 563. 1838?—*Corticium seriale* (Bres.) Bourdot & Galzin, Soc. Myc. Fr. Bul. **27:** 253. 1911 (Forme 2).

Type: type distribution in Sydow, Myc. Germ., 1.

Fructifications long and widely effused, thin, closely adnate, very variable in color, smoke-gray and pale olive-buff to wood-brown in the herbarium, even, sometimes cracked; the margin thinning out, indeterminate; in section 60–180 μ thick, not colored, composed of densely arranged, erect hyphae about 3 μ in diameter, with the outer portion of the wall gelatinously modified and indistinct, and of some scattered, yellowish or brownish, somewhat spherical masses 9–12 μ in diameter, immersed near the substratum; gloeocystidia in the unusual form of irregular, immersed spherical masses 9–12 μ in diameter; cystidia not incrusted, tapering to a sharp apex, 3–5 μ in diameter, protruding up to 30μ; spores hyaline, even, curved, 4–6 × 1–2 μ.

Fructifications 3–12 cm. long, 2–5 cm. wide.

On decaying wood of logs of *Pinus, Abies, Tsuga,* and *Thuja.* Europe, New York, and Washington. August to May.

P. serialis resembles in aspect *P. Cacao* and *Corticium lividum;*

from the latter, the more common species, it is distinguished by its cystidia and from both by the immersed, spherical, colored masses near the substratum, such as were described and figured for another species with larger spores as gloeocystidia by von Höhnel & Litschauer in K. Akad. Wiss. Wien Sitzungsber. **116**: 838. 1907.

Specimens examined:

Exsiccati: Sydow, Myc. Germ., 1.

Sweden: Femsjö, *E. A. Burt*, two gatherings.

Germany: Brandenburg, *P. Sydow*, type distribution, in Sydow, Myc. Germ., 1, and comm. by Bresadola.

New York: Floodwood, *C. H. Peck, 8.*

Washington: Sedro Woolley, *C. J. Humphrey, 7538.*

90. P. typhicola Burt, n. sp.

Type: in Burt Herb.

Fructifications effused, thin, adnate, somewhat membranaceous, tender, between whitish and pale olive-buff in the herbarium, even, not shining, not cracked, the margin thinning out, indeterminate; in section 60–75 μ thick, not colored near the substratum, composed of suberect, densely interwoven, thin-walled hyphae 2–3 μ in diameter, indistinct, and of incrusted cystidia and a few gloeocystidia; gloeocystidia flexuous, 25–30 × 4–6 μ, few present; cystidia incrusted, 40 × 15 μ, immersed, starting from the substratum; paraphyses with filiform tips about ½–1 μ in diameter, with 1 or 2 lateral branches but not antler-shaped, in surface of hymenium; spores hyaline, even, 8–12 × 3½–4 μ, two to a basidium.

Fructifications 2–10 mm. in diameter.

On dead *Typha latifolia.* New York.

This specimen was at first doubtfully referred to *P. phyllophila* which it resembles in aspect and somewhat in structure, but it is thicker, more dense, has gloeocystidia, and does not have conspicuous antler-shaped paraphyses. Reference to *Epithele Typhae,* which I have been unable to find in our North American species, is precluded by the absence of hyphal fascicles.

Specimens examined:

New York: Ithaca, *G. F. Atkinson, 261,* type.

91. P. filamentosa (Berk. & Curtis) Burt in Coker, Elisha Mitchell Scientif. Soc. Jour. **36:** 162. *pl. 32, f. 5, 6.* 1921.

Corticium filamentosum Berkeley & Curtis, Grevillea **1:** 178. 1873; Sacc. Syll. Fung. **6:** 619. 1888; Massee, Linn. Soc. Bot. Jour. **27:** 154. 1890.—(In part) *Corticium Petersii* Berkeley & Curtis, Grevillea **1:** 177. 1873.—*Peniophora unicolor* Peck, N. Y. State Mus. Rept. **43:** 66. 1890; Sacc. Syll. Fung. **9:** 239. 1891.—An *Corticium radicatum* P. Hennings, Pilze Ostafrikas, 54. 1895; Sacc. Syll. Fung. **14:** 222. 1899? See v. Höhnel & Litschauer, K. Akad. Wiss. Wien Sitzungsber. **117:** 1093. 1908.

Type: in Kew Herb. and Curtis Herb.

Fructifications broadly effused, membranaceous, loosely adnate, separable when moistened, soft, drying Isabella color to buffy citrine, the margin and subiculum concolorous with, or a little paler than, the hymenium, often extended into, or connected with, branching mycelial strands or cords; in section 150–400 μ thick, colored, with the hyphae loosely interwoven, thin-walled, 3–4 μ in diameter, densely incrusted with ochraceous granules which are not soluble in lactic acid preparations, but dissolve quickly when sections are treated with potassium hydrate solution and leave the sections bleached, after first becoming vinaceous; cystidia incrusted, 40–50 × 6–8μ, protruding up to 40 μ, confined to the hymenial layer; spores white in spore collection, even, 3–5 × 2–3 μ.

Fructifications 2–10 cm. long, 1–3 cm. broad; sometimes much larger on logs by confluence longitudinally.

On decaying wood and logs and fallen limbs of frondose species. Germany, Canada to Alabama, and westward to Arizona, in Mexico, the West Indies, and Japan. July to January. Common.

Although colored like a *Coniophora, P. filamentosa* is easily recognized by its marginal mycelial strands, small and white spores, and hyphae incrusted with ochraceous granules which are soluble in the 7 per cent solution of potassium hydrate with which sections are usually treated. Since the original description of *Corticium Petersii* combines the characters of both *Peniophora sanguinea* and *P. filamentosa*, and one of the types is of one species

and the other of the other, *C. Petersii* has been reduced to synonymy and *C. filamentosum* of the same authors adopted for the present species.

Specimens examined:

Exsiccati: Ravenel, Fungi Car. 5: 28, the type distribution of *Corticium Petersii.*

Germany: Hannover, *Engelke* (in Mo. Bot. Gard. Herb., 43481, under the name *Peniophora radicata*).

Canada: *J. Macoun, 298;* Lower St. Lawrence Valley, *J. Macoun, 6, 28, 38.*

New Hampshire: Franconia, *W. G. Farlow, 26.*

Vermont: Middlebury, *E. A. Burt,* two gatherings.

New York: Albany, *L. O. Overholts, 3389* (in Mo. Bot. Gard. Herb., 10179); Altamont, *C. H. Peck* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 55211); Bolton, *C. H. Peck, 15;* Bolton Landing, *C. H. Peck* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 55975, 56021); Cazenovia, *L. M. Underwood, 46* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61405); East Berne, *C. H. Peck* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 56016); East Galway, *E. A. Burt,* two gatherings; East Schagticoke, *C. H. Peck* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 56022); North Elba, *C. H. Kauffman, 9* (in Mo. Bot. Gard. Herb., 16769); North Greenbush, *H. D. House, 14.235* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 14840, 44734); Hudson Falls, *S. H. Burnham, 23* (in Mo. Bot. Gard. Herb., 54487); Ithaca, *G. F. Atkinson, 7892;* Staten Island, *W. H. Ballou* (in Mo. Bot. Gard. Herb., 10276); Syracuse, *L. M. Underwood,* type of *Peniophora unicolor* (in N. Y. State Mus. Herb.).

New Jersey: *J. B. Ellis,* comm. by W. G. Farlow (in Mo. Bot. Gard. Herb., 44645); Newfield, *J. B. Ellis, 1518,* comm. by W. G. Farlow (in Mo. Bot. Gard. Herb., 14645); Orange, *L. M. Underwood* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61576).

Maryland: Takoma Park, *C. L. Shear, 1097.*

North Carolina: Chapel Hill, *J. N. Couch,* Univ. N. C. Herb., 4607 (in Mo. Bot. Gard. Herb., 57423).

Alabama: *Peters,* type (in Kew Herb., and Curtis Herb., 6119),

and in Ravenel, Fungi Car. **5**: 28; Montgomery County, *R. P. Burke, 425, 660* (in Mo. Bot. Gard. Herb., 57270, 63086).

Kentucky: Crittenden, *C. G. Lloyd* (in Lloyd Herb., 10113, and Mo. Bot. Gard. Herb., 65627).

Ohio: *C. G. Lloyd, 3883;* Cincinnati, *C. G. Lloyd, 4504.*

Michigan: New Richmond, *C. H. Kauffman, 49* (in Mo. Bot. Gard. Herb., 3734).

Illinois: Riverside, *E. T. & S. A. Harper, 852.*

Missouri: Columbia, *B. M. Duggar, 447.*

Arizona: Fort Valley Experiment Station, *W. H. Long, 21121* (in Mo. Bot. Gard. Herb., 55138).

Mexico: Jalapa, *W. A. & E. L. Murrill, 178, 327,* comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 44969, 54496).

Cuba: *C. G. Lloyd, 420* (in Mo. Bot. Gard. Herb., 55173); Omaja, *C. J. Humphrey, 2782* (in Mo. Bot. Gard. Herb., 14850).

Jamaica: Troy and Tyre, *W. A. Murrill & W. Harris, 911,* comm. by N. Y. Bot. Gard. Herb.

Japan: Prov. Bunga, *A. Yasuda, 113* (in Mo. Bot. Gard. Herb., 59463).

92. P. viticola (Schw.) v. Höhnel & Litschauer, K. Akad. Wiss. Wien Sitzungsber. **116**: 779. *text f. 4.* 1907.

Thelephora viticola Schweinitz, Naturforsch. Ges. Leipzig Schrift. **1**: 107. 1822; Am. Phil. Soc. Trans. N. S. **4**: 168. 1832; Fries, Elenchus Fung. **1**: 205. 1828.—*Corticium viticola* Fries, Epicr. 561. 1838; Sacc. Syll. Fung. **6**: 617. 1888; Massee, Linn. Soc. Bot. Jour. **27**: 146. 1890; Coker, Elisha Mitchell Scientif. Soc. Jour. **36**: 172. *pl. 33, f. 6.* 1921.—*Corticium crocicreas* Berkeley & Curtis, Grevillea **1**: 178. 1873; Sacc. Syll. Fung. **6**: 616. 1888. Not *C. crocicreas* Massee nor v. Höhnel & Litschauer.—*Corticium subaurantiacum* Peck, N. Y. State Mus. Rept. **43**: 67. 1890; Sacc. Syll. Fung. **9**: 230. 1891.

Type: in Schweinitz Herb.

Fructifications effused, thin, adnate, soft, small portions separable when moistened, the tomentose subiculum and margin ochraceous orange, the hymenium even, grayish to buff-yellow and pruinose; in section 150–400 μ thick, with the denser and broader subhymenial region ochraceous orange and the more

loosely interwoven region next to the substratum yellow, the loosely interwoven hyphae thin-walled, 2–4 μ in diameter, not nodose-septate, incrusted with colored granules which give the color to the fructification, and are destroyed and dissolved by the action of potassium hydrate solution leaving the sections bleached; no gloeocystidia; cystidia not incrusted, thin-walled, cylindric, 6–9 μ in diameter, protruding 25–40 μ beyond the basidia; basidia with 4 sterigmata; spores white in collection on slide, even, 7–8 × 4–5 μ.

Fructifications 1–2 cm. in diameter, becoming confluent over areas 3–8 cm. long, 2–5 cm. wide.

On bark and wood of decaying *Vitis, Abies, Acer,* and *Fagus.* Vermont to North Carolina, Kentucky, and Arkansas. July to October. Abundant locally.

P. viticola is conspicuous by the large, brilliant orange fructifications with paler, pruinose fertile hymenium which occur on rotting large stems of the wild grape and on logs in deep mountain forests. The bleaching of the sections through destruction and solution of the incrusting pigment granules is common also to *P. filamentosa,* from which *P. viticola* differs in more orange color and larger spores.

Specimens examined:

Exsiccati: Ravenel, Fungi Car. 3: 34.

Vermont: Bread Loaf, *E. A. Burt;* Little Notch, *E. A. Burt;* Middlebury, *E. A. Burt,* determination as *Corticium subaurantiacum* confirmed by Peck.

New York: Ampersand, *C. H. Peck* (in N. Y. State Mus. Herb., T 20, and Mo. Bot. Gard. Herb., 54638); Clear Water, *G. F. Atkinson, 5043* (in Cornell Univ. Herb.); Floodwood, *E. A. Burt;* Lake Placid, *W. A. & E. L. Murrill, 104* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 57344); Long Lake, *A. H. W. Povah, 13* (in Mo. Bot. Gard. Herb., 9084); Marcy Trail, *C. H. Peck* (in N. Y. State Mus. Herb., T 19, and Mo. Bot. Gard. Herb., 54637); North Elba, *C. H. Kauffman, 3* (in Mo. Bot. Gard. Herb., 6686); Ray Brook, *C. H. Peck* (in N. Y. State Mus. Herb., T 21, and Mo. Bot. Gard. Herb., 54639); Undercliff, comm. by Univ. Wis. Herb., 45.

North Carolina: Salem, *Schweinitz,* type (in Herb. Schweinitz).

Alabama: *Peters,* in Ravenel, Fungi Car. **3**: 34, and as *Corticium crocicreas* Berk. & Curtis, type (in Kew Herb. and in Curtis Herb., 4542).

Kentucky: Mammoth Cave, *C. G. Lloyd, 1601, 2661,* and another specimen comm. by Ellis Herb.

Arkansas: Fordyce, *C. J. Humphrey, 5799.*

93. P. sulphurina (Karst.) v. Höhnel & Litschauer, K. Akad. Wiss. Wien Sitzungsber. **115**: 1573. 1906.

Tomentella sulphurina Karsten, Finska Vet.-Soc. Bidrag Natur och Folk **48**: 420. 1889.—*Hypochnus sulphurinus* (Karst.) Sacc. Syll. Fung. **9**: 243. 1891.

Type: authentic specimen—perhaps part of type—in Burt Herb.

Fructifications effused, adnate, the hymenium drying clay color, thin, brittle, even, here and there cracked and showing the mustard-yellow subiculum, the margin fibrillose-byssoid, mustard-yellow; in section 150–400 μ thick, pale yellow, with the hyphae loosely arranged, thin-walled, 4–6 μ in diameter, occasionally nodose-septate, some hyphae granule-incrusted; cystidia hair-like, not incrusted, 3–6 μ in diameter, protruding up to 30 μ, not numerous; spores hyaline, even, 3–4 × 2–2½ μ.

Fructifications 2–6 cm. long, 1–2 cm. broad.

On coniferous bark usually. In Finland, from New Hampshire to Alabama and westward to British Columbia and Oregon. August to November. Rare.

The American gatherings referred to *P. sulphurina* are a little paler than the European and the sections lose most of their color when floated on alcohol in sectioning so as to become not distinctly colored in section. In other respects our specimens agree so well with the authentic specimen that I believe they should be included in this species. Potassium hydrate solution does not change the color of the sections to vinaceous and bleach them as it does sections of *P. filamentosa.*

Specimens examined:

Finland: Jalasjärvi, authentic specimen from *P. A. Karsten.*

New Hampshire: Chocorua, *W. G. Farlow* (in Mo. Bot. Gard. Herb., 7872).

New York: Fall Creek, *G. F. Atkinson, 7993;* Ithaca, *E. J. Petey,* comm. by C. J. Humphrey, 471; Rainbow, *C. H. Peck* (in

N. Y. State Mus. Herb., T 32, and Mo. Bot. Gard. Herb., 54656); Yates, *C. H. Peck, 33.*

Pennsylvania: Delaware Water Gap, *W. A. Murrill,* comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 61469).

New Jersey: Newfield, *J. B. Ellis,* comm. by W. G. Farlow (in Mo. Bot. Gard. Herb., 7764, 14290, 14770).

District of Columbia: Takoma Park, *C. L. Shear, 1348.*

Alabama: Montgomery, *R. P. Burke, 145* (in Mo. Bot. Gard. Herb., 10359).

Kentucky: Crittenden, *C. G. Lloyd, 3120.*

South Dakota: Sylvan Lake, Custer, *J. R. Weir, 10011* (in Mo. Bot. Gard. Herb., 55792).

Idaho: Priest River, *J. R. Weir, 30.*

British Columbia: Squamish, *J. Macoun, 497, 534* (in Mo. Bot. Gard. Herb., 55182, 55181).

Oregon: Eugene, *C. J. Humphrey, 1051.*

94. P. carnosa Burt, n. sp.

Type: in Burt Herb., Mo. Bot. Gard. Herb., and N. Y. State Mus. Herb.

Fructifications long and broadly effused, thick, fleshy-membranaceous, adnate, barium-yellow to honey-yellow, of the same color within where cracked, the margin determinate, thinning out, somewhat radiate-fibrillose; in section 400–700 μ thick, colored like the hymenium in thick sections but very thin sections hyaline, somewhat zoned, composed of a very broad hyphal layer bearing a hymenial layer 50–60 μ thick, the hyphae hyaline, 5–6 μ in diameter; no gloeocystidia; cystidia hair-like, not incrusted, tapering to a sharp tip, 4 μ in diameter at the base, protruding up to 30 μ beyond the basidia, very numerous in the hymenial surface; basidia 4-spored; spores white in spore collection, even, 4–5 × 2–2½ μ.

Fructifications 3–12 cm. long, 1½–6 cm. wide.

On bark and wood of coniferous logs such as *Pinus, Abies, Picea, Pseudotsuga, Juniperus,* and *Larix,* rarely on frondose species. In mountains of New England, New York, Minnesota, and British Columbia and Montana to New Mexico. May to October. Common in the Rocky Mountain forests.

P. carnosa may be recognized at sight by its large, thick, yellow fructifications occurring on coniferous logs in forests of the White Mountains, Adirondacks, and the Rocky Mountains. The abundant cystidia are too small to be visible with a lens, hence it is necessary to examine sections with a microscope to recognize the species as a *Peniophora* rather than a *Corticium*. It does not have the mustard-yellow subiculum of *P. sulphurina* nor does its hymenial layer flake away from the substratum as in the latter.

Specimens examined:

Maine: Piscataquis County, *W. A. Murrill, 2311* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61596).

New Hampshire: Chocorua, *E. A. Burt;* Intervale, *L. O. Overholts, 5039* (in Mo. Bot. Gard. Herb., 56351); North Conway, *L. O. Overholts, 4732* (in Mo. Bot. Gard. Herb., 56117).

New York: Hague, *C. H. Peck*, type (in Burt Herb., N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 56019); North Elba, *C. H. Kauffman, 4* (in Mo. Bot. Gard. Herb., 21307).

Minnesota: Cass Lake, *J. R. Weir, 392* (in Mo. Bot. Gard. Herb., 12436).

Montana: Fortine, *E. E. Hubert*, comm. by J. R. Weir, 12013 (in Mo. Bot. Gard. Herb., 63323); Missoula, *J. R. Weir, 383* (in Mo. Bot. Gard. Herb., 20892).

Idaho: Meadow Creek, *E. E. Hubert*, comm. by J. R. Weir, 11669, 11671 (in Mo. Bot. Gard. Herb., 63308, 63310); Priest River, *E. E. Hubert*, comm. by J. R. Weir, 11738 (in Mo. Bot. Gard. Herb., 63311), *J. R. Weir, 355, 9100* (in Mo. Bot. Gard. Herb., 10883, 55955), and *26, 32, 51, 57, 62, 69.*

British Columbia: Kootenai Mts. near Salmo, *J. R. Weir, 450, 458, 464, 467, 468, 469, 479, 523, 530* (in Mo. Bot. Gard. Herb., 8767, 9121, 12613, 12287, 8766, 12534, 12907, 20976, and 16078 respectively).

Washington: Olympia, *C. J. Humphrey, 6291.*

New Mexico: Cienega Canyon, *W. H. Long, 21470, 21515, 21561* (in Mo. Bot. Gard. Herb., 55148, 55149, 55150); Sulphur Canyon, *W. H. Long, 21411* (in Mo. Bot. Gard. Herb., 55147); Tyom Experiment Station, *W. H. Long, 21935* (in Mo. Bot. Gard. Herb., 55151).

95. P. citrinella (B. & C.) Burt, n. comb.

Corticium citrinellum Berkeley & Curtis, Linn. Soc. Bot. Jour. **10**: 336. 1868; Sacc. Syll. Fung. **6**: 616. 1888; Massee, Linn. Soc. Bot. Jour. **27**: 147. 1890.

Type: in Curtis Herb. and probably in Kew Herb.

Fructifications effused, thin, tender, small pieces separable when moistened, barium-yellow, cracked and showing a byssoid, barium-yellow subiculum, the margin thinning out, sometimes with barium-yellow mycelial strands; in section 120–300 μ thick, barely barium-yellow when but slightly magnified but not perceptibly colored under high magnification and wholly bleached by treatment with potassium hydrate solution, 2-layered, with the broader layer next to the substratum and composed of loosely interwoven hyphae 2½–3 μ in diameter under the incrustation of scattered, coarse granules, not nodose-septate, and with the hymenial layer 90 μ thick, compact; no gloeocystidia; wholly immersed cystidia few, incrusted, 15 × 9 μ; protruding cystidia hair-like, short, 3–4½ μ in diameter, protruding up to 12 μ; spores hyaline, even, 3–4 × 2–3 μ.

Fructifications 1–3 cm. long, ½–1 cm. wide.

On bark of logwood limb on the ground. West Indies. October to March.

P. citrinella belongs in the group of species with *P. sulphurina*, *P. limonia*, *P. Burtii*, and *P. subiculosa*, and appears distinct from each of these when specimens are compared with one another. It has priority over all the others as a species. Its distinguishing combination of characters is barium-yellow color, cracked hymenium showing subiculum of the same color, color bleached by treatment with potassium hydrate solution, short cystidia, and occurrence on frondose bark.

Specimens examined:

Cuba: *C. Wright, 844,* type (in Curtis Herb.); Pinar del Rio Province, *Earle & Murrill, 381,* comm. by N. Y. Bot. Gard. Herb.; Santa Clara Province, *Earle & Murrill, 427,* comm. by N. Y. Bot. Gard. Herb.

Jamaica: Hope Gardens, *F. S. Earle, 164,* comm. by N. Y. Bot. Gard. Herb.

96. P. Sacchari Burt, n. sp.

Type: in Mo. Bot. Gard. Herb.

Fructifications longitudinally effused, adnate, thin, somewhat membranaceous, noted as yellow when growing but now clay color in the herbarium, even, cracking into polygonal masses about ½ mm. in diameter which may curl away from the substratum more or less and show the exposed tissue colored like the hymenium, the margin thinning out, of finely interwoven hyphae; in section 75–110 μ thick, with the thin sections not colored appreciably, composed of densely arranged, suberect hyphae about 3 μ in diameter, not incrusted, not nodose-septate; no gloeocystidia; cystidia not incrusted, tapering towards the apex, 5–6 μ in diameter, protruding up to 30 μ; spores hyaline, even, 3½–4 × 2½–3 μ.

Fructifications 8 cm. long, 10–13 mm. wide.

On cane trash of *Saccharum officinarum*. Porto Rico. January.

P. Sacchari was listed by Johnston & Stevenson, Dept. of Agr. Porto Rico Jour. **1**: 227. 1917, as *Peniophora* sp. It has not been received from other sources and is apparently a species local to Porto Rico or with a preference for a sugar-cane substratum. It should be conspicuous by its yellow color. *P. citrinella* is thicker and has incrusted cystidia.

Specimens examined:

Porto Rico: Rio Piedras, *J. A. Stevenson, 1204*, type (in Mo. Bot. Gard. Herb., 11787).

97. P. medioburiensis Burt, n. sp.

Type: in Burt Herb.

Fructifications effused, thin, felty, small pieces separable when moistened, becoming in the herbarium between light grayish olive and deep olive-buff, the margin thinning out and sometimes paler; in section 200–300 μ thick, colored like the surface, somewhat zonate, composed of suberect, thin-walled, even-walled hyphae 3 μ in diameter and of incrusted hyphae 5 μ in diameter over the incrustation; no gloeocystidia; cystidia usually not incrusted, sometimes granule-incrusted, cylindric, obtuse, 6–8 μ in diameter, protruding up to 30 μ beyond the basidia; basidia with 4 large sterigmata up to 6 μ long; spores white in spore collection, cylindric, 8–14 × 4½–6 μ.

Fructifications 5 mm.–3 cm. long, 5 mm.–1½ cm. wide.

On wood and bark of fallen, rotten limbs of *Carya*. Middlebury, Vermont. July. Seen but once.

This species is of felty or fibrillose structure like some species of *Hypochnus*, not at all waxy, and of dull, olivaceous color so as to be very inconspicuous on the fallen decaying limbs on which found. So few species of *Peniophora* have spores up to 14 μ long that the spore dimensions should prove in this instance an important character for recognition of *P. medioburiensis*.

Specimens examined:

Vermont: Battell Ledge, Middlebury, *E. A. Burt*, type.

98. P. subsulphurea (Karst.) v. Höhnel & Litschauer, K. Akad. Wiss. Wien Sitzungsber. **115:** 1580, 1592. 1906; Bourdot & Galzin, Soc. Myc. Fr. Bul. **28:** 388. 1913.

Corticium subsulphureum Karsten, Soc. pro Fauna et Fl. Fennica Meddel. **6:** 12. 1881; Sacc. Syll. Fung. **6:** 632. 1888; Massee, Linn. Soc. Bot. Jour. **27:** 148. 1890.—*Xerocarpus subsulphureus* Karsten, Finska Vet.-Soc. Bidrag Natur och Folk **37:** 138. 1882; **48:** 417. 1889. See v. Höhnel & Litschauer, K. Akad. Wiss. Wien Sitzungsber. **117:** 1093. 1908.—*Corticium subincarnatum* Peck, N. Y. State Mus. Rept. **42:** 122. 1889; Sacc. Syll. Fung. **9:** 232. 1891.

Type: authentic specimen in Burt Herb., and specimen cited by Karsten in Roumeguere, Fungi Gall., 4307.

Fructifications longitudinally effused, adnate, at first citron-yellow, soon cinnamon-buff, even, pulverulent, the margin thinning out, citron-yellow; in section 150–400 μ thick, with the hymenial layer and that next to the substratum usually slightly colored, the hyphae suberect and branching or loosely interwoven, thin-walled, hyaline, 3–4 μ in diameter, nodose-septate, not incrusted except perhaps with a few minute grains in the subhymenium; hymenium becoming 2-layered; cystidia hair-like, thin-walled, even or with a few incrusting granules, 4–5 μ in diameter, protruding up to 40 μ; spores white in spore-collection, 4–5½ × 2–2½ μ.

Fructifications 4–10 cm. long, 1–3 cm. broad.

On decaying decorticated wood of *Pinus* and *Abies* in mountain

forests. Europe and northern United States and Canada westward to Idaho and Manitoba. July to October. Uncommon.

This species may be recognized by its cinnamon-buff, yellow-margined, closely adnate fructifications which occur, so far as known at present, only on bare wood of spruce and pine. I cannot understand how von Höhnel & Litschauer, *loc. cit.*, could have regarded *P. subsulphurea* as perhaps not specifically distinct from the Hannover specimens of *P. radicata* (*P. filamentosa*) which have their hyphae heavily incrusted with a yellow matter soluble in potassium hydrate solution, and much larger, more incrusted cystidia, and fructifications only loosely adnate when present on decorticated wood and margined with conspicuous mycelial strands.

Specimens examined:

Finland: Mustiala, *P. A. Karsten*, authentic specimen of *Xerocarpus subsulphureus*.

Sweden: *L. Romell, 182*.

France: Aveyron, *A. Galzin, 21033*, comm. by H. Bourdot, 18426.

Canada: Lower St. Lawrence Valley, *J. Macoun, 62*.

New York: Cascade, *C. H. Peck* (in N. Y. State Mus. Herb., T. 31, and Mo. Bot. Gard. Herb., 56072); Clear Lake, *G. F. Atkinson, 5048;* Floodwood, *E. A. Burt, C. H. Peck, 5*, and an unnumbered specimen (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 56017); North Elba, *C. H. Peck*, type of *Corticium subincarnatum* (in N. Y. State Mus. Herb.).

Minnesota: Vermilion Lake, *E. W. D. Holway, 155*, the *Corticium epichlorum* of Geol. & Nat. Hist. Survey of Minn. but not *C. epichlorum* Berk. & Curtis (in U. S. Dept. Agr. Herb. and Burt Herb.).

Montana: Melrose, *E. E. Hubert*, comm. by J. R. Weir, 11431 (in Mo. Bot. Gard. Herb., 63270).

Idaho: Priest River, *J. R. Weir, 14*.

Manitoba: Norway House, *G. R. Bisby, 1478* (in Mo. Bot. Gard. Herb., 61660).

99. **P. martiana** (Berk. & Curtis) Burt, n. comb.

Corticium martianum Berkeley & Curtis, Grevillea **1**: 179.

1873; Peck, N. Y. State Mus. Rept. **30**: 48. 1879; **40**: 76. 1887; Sacc. Syll. Fung. **6**: 633. 1888; Massee, Linn. Soc. Bot. Jour. **27**: 144. 1890.

Type: type distribution in Ravenel, Fungi Car. **5**: 30.

Fructifications widely effused, rather thick, somewhat tubercular or rugose, waxy, drying cinnamon to liver-brown and burnt umber and so hard as to require prolonged moistening before sectioning, the margin thinning out; in section 200–400 μ thick, colored like the hymenium, becoming dark vinaceous when treated with potassium hydrate solution, 2-layered, with the layer next to the substratum composed of longitudinally arranged, honey-yellow hyphae 3 μ in diameter, and with the hymenial layer thicker, denser, darker, and composed of densely interwoven hyphae and scattered cystidia; no gloeocystidia; cystidia incrusted, conical, 30–45 × 8–12 μ, wholly immersed or protruding up to 30 μ beyond the basidia; spores hyaline, even, 4–4½ × 2½–3 μ.

Fructifications 1–10 cm. long, 1–4 cm. wide.

On very rotten wood of frondose species—*Betula* and *Populus* noted. Massachusetts to Alabama and in Ohio and Idaho. September to November. Rare.

P. martiana is usually blood-red in color, with substance of the same color, and with surface so tubercular or with so irregular folds as to suggest a *Phlebia*. It is likely to be confused with *Phlebia hydnoidea* Schw., from which it is sharply distinct by the more toothed surface and slightly colored cystidia of the latter.

Specimens examined:

Exsiccati: Ravenel, Fungi Car. **5**: 30, type distribution.

Massachusetts: *Murray* (in Curtis Herb., 6251).

New York: Ithaca, *H. L. Jackson*, comm. by Cornell Univ. Herb., 18659; Keene Valley, Adirondack Mts., *W. G. Farlow.*

West Virginia: Eglon, *C. G. Lloyd, 02678.*

Florida: *R. Thaxter, 14* (in Mo. Bot. Gard. Herb., 43934).

Alabama: *Peters*, in Ravenel, Fungi Car. **5**: 30.

Ohio: College Hill, *C. G. Lloyd, 1659.*

Idaho: Coolin, *J. R. Weir, 11116* (in Mo. Bot. Gard. Herb.. 63251).

100. P. alutaria Burt, n. sp.

Type: in Burt Herb.

Fructifications effused, closely adnate, very thin, not at all separable, clay color in the herbarium, somewhat lacunose in some places, somewhat granular where thickest, the margin thinning out; in section 120–160 μ thick, showing a little color when only little magnified and giving the characteristic color to the fructification but hyaline under high magnification, composed of densely arranged, interwoven, suberect hyphae 3–3½ μ in diameter, not incrusted; no gloeocystidia; cystidia of two kinds: cylindric, hair-like, flexuous cystidia 3–3½ μ in diameter, not incrusted protrude up to 30 μ beyond the basidia and sometimes have capitate tips; smaller incrusted cystidia 10 × 3 μ are present at surface of hymenium; basidia 4-spored; spores white in spore collection, even, subglobose, 3–3½ × 3 μ.

Fragmentary pieces of fructifications are up to 5 cm. long, 2 cm. wide.

Type on wood of hardwood log of a frondose species in mountain woods, also on *Larix*. Vermont and Michigan. November. Rare.

P. alutaria seems possible of recognition by its clay color, closely adnate fructifications, and small spores and cystidia.

Specimens examined:

Vermont: Little Notch, Bristol, *E. A. Burt*, type.

Michigan: pole yard, Escanaba, *C. J. Humphrey, 1783* (in Mo. Bot. Gard. Herb., 42931).

101. P. separans Burt, n. sp.

Type: in Mo. Bot. Gard. Herb. and Dodge Herb.

Fructifications broadly effused, adnate, somewhat membranaceous, small pieces separable when moistened, between pale ochraceous buff and avellaneous in the herbarium, even, somewhat cracked and showing the darker substance in the sides of the fissures, the margin thinning out, slightly darker, somewhat radiately fibrillose, adnate; in section 300–350 μ thick, colored, stratose, each stratum 2-layered, the supporting layer composed of densely and longitudinally interwoven, slightly colored hyphae 3–3½ μ in diameter, the hymenial layer 75–

120 μ thick, composed of densely arranged, erect tissue; no gloeocystidia nor conducting organs; cystidia incrusted, 40–50 × 8–15 μ, numerous, immersed, starting from the base of the hymenial layer; spores hyaline, even, 8–10 × 2–3 μ.

Fructifications probably large, for those studied are 4 cm. long by 4 cm. wide and broken off on three sides.

On bark of coniferous log. British Columbia. September.

P. separans has some resemblance in color and aspect to *P. ciliata* and resupinate *Stereum sanguinolentum*, but the stouter, wholly immersed cystidia distinguish *P. separans* from the former species, and the presence of cystidia and lack of conducting organs from the latter. The type has two strata, the other specimen only a single stratum of two layers.

Specimens examined:

British Columbia: Porcupine Creek, south of Beavermouth, *C. W. Dodge, 1702*, type, and *1704* (in Mo. Bot. Gard. Herb., 58797, 58798, and in Dodge Herb.).

102. P. stratosa Burt, n. sp.

Type: in Mo. Bot. Gard. Herb.

Fructifications broadly effused, adnate, thick, stratose, somewhat cartilaginous-coriaceous, hard when dry, becoming pinkish buff to light ochraceous buff in the herbarium, cracking in drying and showing the stratose context, the margin thinning out; in section 700 μ thick, pale yellowish, composed of 8 strata in the type, with the hyphae hyaline, densely interwoven and conglutinate, about 2–2½ μ in diameter; cystidia incrusted, conical, 45–55 × 10–13 μ, protruding up to 40 μ, present in all strata but more abundant and conspicuous in the outer half of the fructification and less distinct and perhaps becoming absorbed in the more deeply buried strata; spores copious, hyaline, even, 4–5 × 2–2½ μ.

Fructification 8 cm. long, 3½ cm. wide in the single piece constituting the type, which has natural margin on one side only and was broken from a larger mass.

On *Quercus densiflora* and *Eucalyptus*. California and Mexico. September.

P. stratosa is related to *P. similis* but has larger cystidia and spores.

Specimens examined:

California: Pinehurst, *E. E. Bethel, 26273* (in Mo. Bot. Gard. Herb., 55437); Redwood Park, *W. H. Long, 18514*, type (in Mo. Bot. Gard. Herb., 55065).

Mexico: *A. Dampf*, comm. by J. R. Weir, 63537 (in Mo. Bot. Gard. Herb., 63710).

103. P. tabacina Burt, n. sp.

Type: in Burt Herb.

Fructifications effused, adnate, tawny olive to snuff-brown, the hymenium becoming cracked and showing in the fissures the concolorous subiculum, the margin thinning out, colored like the hymenium; in structure 150–400 μ thick, tawny olive throughout, 2-layered, with the layer next to the substratum composed of loosely interwoven, even-walled, colored hyphae 3–3½ μ in diameter, nodose-septate, not incrusted, and the hymenial layer about equal in thickness to the other, with its hyphae densely crowded together in a palisade layer and bearing basidia and sterigmata and containing some somewhat colored spores; cystidia not incrusted, cylindric, 6–8 μ in diameter, protruding up to 80 μ; basidiospores hyaline, even, 6–9 × 2½–3 μ, copious; slightly colored spores 9 × 3 μ are present in the deeper portion of the hymenial layer of the type specimen.

Fructifications 2–9 cm. long, 1–2½ cm. broad.

On decaying coniferous wood and bark of logs. Wisconsin, Colorado, Washington, and Oregon. July to November. Rare.

P. tabacina is distinguished by its tobacco color throughout and hyphae and cystidia lacking incrustation. It lacks the radiate filamentous margin of *P. filamentosa* of somewhat similar color as well as the hyphal incrustation of the latter. The presence of colored spores in the subhymenium is suggestive of *Stereum rugisporum*, a species of the same color, occurring on coniferous substrata in the same regions, and more abundant material may show that *P. tabacina* is the thin, first-stratum stage of the latter, but the fructifications at hand are closely adnate to the substratum rather than loosely connected with it by the tomentose layer characteristic of many resupinate Stereums.

Specimens examined:

Wisconsin: Oconto Falls, *C. J. Humphrey, 9445* (in Mo. Bot. Gard. Herb., 57176).

Colorado: Ouray, *C. L. Shear, 1185,* type.

British Columbia: Agassiz, *J. R. Weir, 330* (in Mo. Bot. Gard. Herb., 63728); Sidney, *J. Macoun, 19* (in Mo. Bot. Gard. Herb., 5734).

Washington: Olympia, *C. J. Humphrey, 6343;* Seattle, *C. J. Humphrey, 6456;* Sedro-Woolley, *C. J. Humphrey, 7578* (in Mo. Bot. Gard. Herb., 10753).

Oregon: Corvallis, on prune bark, *Mrs. E. B. Zeller,* comm. by S. M. Zeller, 1871 (in Mo. Bot. Gard. Herb., 56872); Eugene, *C. J. Humphrey, 6096.*

104. P. fusco-marginata Burt, n. sp.

Type: in Burt Herb. and probably in Lloyd Herb.

Fructifications long-effused, membranaceous, separable, becoming pinkish buff to warm buff in the herbarium, not waxy nor cracked, the extreme margin byssoid, fuscous, colored like the supporting hyphal layer next to the substratum; in section 300–320 μ thick, colored next the substratum, 2-layered with (1) the layer next to the substratum composed of longitudinally arranged hyphae 4–5 μ in diameter, not incrusted, not nodose-septate, fuscous along the substratum, becoming colorless above, and (2) the hymenial layer of equal thickness, composed of colorless, erect hyphae somewhat granule-incrusted in an incrusted zone; no gloeocystidia; cystidia not incrusted, 6 μ in diameter at base, tapering to the apex, protruding up to 30–40 μ beyond the basidia; spores hyaline, even, 5–6 × 3–3½ μ.

Fructifications 1–10 cm. long, the largest broken off at both ends, ½–2½ cm. wide.

On bark of fallen decaying frondose limbs. Florida and Louisiana. June and July. Local.

P. fusco-marginata has the unusual character of a colored layer of coarse, fuscous hyphae running over the substratum and only more or less completely covered by the buff, fertile portion of the fructification, so that the protruding colored portion forms a distinctive fuscous margin. The Florida specimen is sterile and too young for confident reference.

Specimens examined:

Florida: Snapper Creek Hammock, *W. A. Murrill, 226,* comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 62083).

Louisiana: St. Martinville, *A. B. Langlois, 1947* and *100,* type, comm. by Lloyd Herb., 2771.

105. P. similis (B. & C.) Massee, Linn. Soc. Bot. Jour. **25:** 147. 1889.

Corticium simile Berk. & Curtis, Linn. Soc. Bot. Jour. **10:** 337. 1868; Sacc. Syll. Fung. **6:** 631. 1888.

Type: in Kew Herb. and Farlow Herb., and a fragment in Burt Herb.

Fructifications broadly effused, adnate, becoming light buff to cream color in the herbarium, somewhat velutinous, cracked, the margin thin; in section marguerite-yellow and darker next to the substratum but with yellow color bleached by action of potassium hydrate solution on the sections, 200–500 μ thick in the type but finally up to 2 mm. thick, composed of densely arranged, erect hyphae 3 μ in diameter, and of great numbers of cystidia; cystidia incrusted, not colored, conical or fusiform, 15–25 × 6–8 μ, very numerous in all regions; spores hyaline, even, allantoid, 4 × 1 μ, borne 4 to a basidium.

Fructifications "spreading for several inches." Fragmentary specimens examined are 1–4 cm. in diameter.

On under side of frondose logs and fallen limbs. Florida, Mexico, West Indies, and Japan. October to March. Probably common.

P. similis closely resembles *Corticium portentosum* in aspect, and I am unable to distinguish it from the latter except by examination with the microscope which reveals the abundant, small, colorless cystidia. *P. tephra* is closely related but does not form as thick fructifications, and its fructifications are less cracked, darker-colored in section, with darker, thicker-walled, more erect and more crowded hyphae, and slightly larger spores.

Specimens examined:

Florida: Cutler Hammock, *W. A. Murrill, 63,* comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 62093); Royal Palm Hammock, *W. A. Murrill, 112, 113, 119, 122, 125,* all

comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 62094–62098, 62110).

Mexico: Guernavaca, *W. A. & E. L. Murrill, 537*, comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 54553); Orizaba, *W. A. & E. L. Murrill, 777*, comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 54612); Xuchiles, near Cordoba, *W. A. & E. L. Murrill, 1211*, comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 54600).

Cuba: *C. Wright, 543*, type (in Kew Herb., Farlow Herb., and Burt Herb.), *C. G. Lloyd, 432* (in Mo. Bot. Gard. Herb., 55171); Alto Cedro, *Earle & Murrill, 433, 553*, both comm. by N. Y. Bot. Gard. Herb.; Ceballos, *C. J. Humphrey, 2678, 2813, 2834* (in Mo. Bot. Gard. Herb., 9087, 14855, 14837); Managua, *Earle & Murrill, 42*, comm. by N. Y. Bot. Gard. Herb.; San Diego de los Baños, *Earle & Murrill, 203, 260, 303*, all comm. by N. Y. Bot. Gard. Herb.

Porto Rico: Rio Piedras, *J. A. Stevenson & R. C. Rose, 6530* (in Mo. Bot. Gard. Herb., 55072).

Bermuda: *B. & J. Dodge*, comm. by N. Y. Bot. Gard. Herb.

Jamaica: Cinchona, *W. A. & E. L. Murrill, 598, 658*, comm. by N. Y. Bot. Gard. Herb.; Troy and Tyre, *W. A. Murrill & W. Harris, 886, 1053*, in part, comm. by N. Y. Bot. Gard. Herb.

Grenada: Grand Etang, *R. Thaxter*, comm. by W. G. Farlow, 7, 8.

Japan: Mt. Tsukikuma, Prov. Bungo, *A. Yasuda, 100* (in Mo. Bot. Gard. Herb., 57018).

106. P. Seymouriana Burt, n. sp.

Type: type in Mo. Bot. Gard. Herb. and probably in Farlow Herb.

Fructifications long and broadly effused, thin, closely adnate, small portions separable when moistened, Verona brown to mummy-brown or fuscous, somewhat velvety, cracking into small areas, the margin determinate, entire; in structure 60–180 μ thick, colored throughout like the hymenium, composed of erect, colored, densely interwoven hyphae 3 μ in diameter, not incrusted, not nodose-septate, and of cystidia in all regions; no gloeocystidia; hymenial surface velvety through very numerous

branched paraphyses having final branches 1 μ in diameter; cystidia incrusted, 20–35 × 12–15 μ, usually wholly immersed; spores not found.

Fructifications 12 cm. long and broken off at ends, 3 cm. wide.

On fallen decaying branches of undetermined frondose species. Georgia and Cuba. August and April. Probably rare.

P. Seymouriana has general aspect suggestive of a resupinate *Hymenochaete* or the effused stroma of an *Hypoxylon*. The fructifications are thinner than those of *P. tephra*, with less numerous cystidia and with the much darker hymenium becoming cracked like that of *Hymenochaete corrugata*.

Specimens examined:

Georgia: Glen Ella, Tallulah Falls, *A. B. Seymour*, type, comm. by Farlow Herb., G (in Mo. Bot. Gard. Herb., 44613).

Cuba: *C. G. Lloyd, 145* (in Mo. Bot. Gard. Herb., 55495).

107. P. laevigata (Fr.) Massee, Linn. Soc. Bot. Jour. **25**: 149. Je. 1889; Karsten, Finska Vet.-Soc. Bidrag Natur och Folk **48**: 426. O. 1889; Bourdot & Galzin, Soc. Myc. Fr. Bul. **28**: 408. 1913; Rea, Brit. Basid. 696. 1922.

Thelephora laevigata Fries, Elenchus Fung. **1**: 224. 1828.—*Corticium laevigatum* Fries, Epicr. 565. 1838; Hym. Eur. 656. 1874; Sacc. Syll. Fung. **6**: 628. 1888.—*Xerocarpus Juniperi* Karsten, Rev. Myc. **3**^{9}: 22. 1881.—*Kneiffia laevigata* (Fr.) Bresadola, Ann. Myc. **1**: 104. 1903.

Fructifications effused, thin, snuff-brown, drab, or pale drab-gray, adnate, small pieces separable from the bark when moistened, becoming cracked when dry, the margin at length free; in section brown, 200 μ thick, composed of very numerous, colored cystidia and thin-walled, hyaline hyphae 2–4 μ in diameter; cystidia colored, cylindric-clavate or fusiform, 25–50 × 5–6 μ, thick-walled and rough above or perhaps somewhat incrusted, very numerous in all regions and giving their color to the trama as a whole; spores hyaline, even, 7–8 × 3–4 μ.

Fructifications 2½–12 cm. long, ½–4 cm. broad.

On bark of *Juniperus*. Canada, New York, and Europe. April and September. Rare.

This species may be recognized by its occurrence on *Juniperus*,

brown color within, and abundance of colored cystidia. European authors record it on bark of living *Juniperus communis*, but the data with the two American specimens which I have seen gave merely the kind of substratum, one of these being *Juniperus virginiana*.

Specimens examined:

Exsiccati: de Thümen, Myc. Univ., 2014, authentic specimen from Karsten of *Xerocarpus Juniperi*.

Sweden: *L. Romell, 104, 105, 106;* Femsjö, *L. Romell, 407.*

Finland: Mustiala, *P. Karsten*, in de Thümen, Myc. Univ., 2014.

Italy (?): locality not given, *G. Bresadola.*

England: Buckden, Yorkshire, *E. M. Wakefield* (in Mo. Bot. Gard. Herb., 57119).

Canada: *J. Macoun, 24.*

New York: Orient, Long Island, *R. Latham* (in Mo. Bot. Gard. Herb., 58907, and Burt Herb.).

108. P. tephra (B. & C.) Cooke, Grevillea **8:** 20. *pl. 123, f. 6.* 1879; Sacc. Syll. Fung. **6:** 643. 1888; Massee, Linn. Soc. Bot. Jour. **25:** 143. 1889.

Corticium tephrum Berk. & Curtis, Linn. Soc. Bot. Jour. **10:** 336. 1868.

Type: in Kew Herb., and in Curtis Herb. mounted on left of card, that on the right is *Stereum albobadium.*

Fructifications effused, adnate, between tilleul-buff and drab, becoming drab in the herbarium, somewhat velutinous, the margin thin, adnate, concolorous; in section brown throughout, zonate, 400–550 μ thick, composed of erect, flexuous, thick-walled, somewhat colored hyphae 3–4 μ in diameter, densely crowded together, and of very numerous cystidia; cystidia coarsely incrusted, conical, sometimes fusiform, 15–25 × 6–9 μ, protruding up to 9–12 μ, not colored, very numerous, throughout the whole fructification; spores hyaline, even, 5 × 2½–3 μ.

Fructifications 2–6 cm. long, ½–2 cm. broad.

On dead wood of frondose species. Mexico, Cuba, Porto Rico, and Bermuda. October to January.

Former accounts of *P. tephra* are erroneous because they were partly based on a gathering of resupinate *Stereum albobadium.*

P. tephra belongs in the group with *P. laevigata* and *P. pruinata* but does not have the colored cystidia of the former nor the pruinose hymenium of the latter. The Australian specimen from Berkeley under the name *P. tephra*, in N. Y. Botanical Garden Herbarium, has colored cystidia and is more probably *P. laevigata*.

Specimens examined:

Mexico: Motzorongo, near Cordoba, *W. A. & E. L. Murrill, 997*, comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 54623).

Cuba: *C. Wright*, type (specimen in Curtis Herb. mounted on left side of card); Ceballos, *C. J. Humphrey, 2692* (in Mo. Bot. Gard. Herb., 21942); Ciego de Avila, *Earle & Murrill, 592*, comm. by N. Y. Bot. Gard. Herb.; Herradura, *Earle & Murrill, 143*, comm. by N. Y. Bot. Gard. Herb.

Porto Rico: Bayamon, *J. A. Stevenson, 6760* (in Mo. Bot. Gard. Herb., 55059).

Bermuda: Agricultural Station, *H. H. Whetzel, Ak* (in Mo. Bot. Gard. Herb., 58909).

109. P. pruinata (B. & C.) Burt, n. comb.

Stereum pruinatum Berk. & Curtis, Linn. Soc. Bot. Jour. **10**: 332. 1868; Sacc. Syll. Fung. **6**: 583. 1888; Massee, Linn. Soc. Bot. Jour. **27**: 198. 1890.

Type: in Kew Herb. and Farlow Herb.

Effused, adnate, drying pale neutral gray to drab-gray, pruinose, cracking when thick, the margin very thin; in section fuscous throughout, becoming zonate and finally 1 mm. thick, composed of densely arranged, erect, colored hyphae 3 μ in diameter and of very numerous cystidia in all regions of the section; cystidia incrusted, fusiform, 18–22 × 6–12 μ; spores hyaline, even, subglobose, about 3–4½ × 2½–3 μ in the few found.

Fructifications probably cover large areas, for those are 5–10 × 1–5 cm. and fractured on 3 or all sides in the specimens seen.

On rotting hardwood logs. Florida, Alabama, Mexico, and the West Indies. June to March. Occasional.

Dried specimens have the livid or cinereous color of some forms of *P. cinerea* but with surface of rather more velvety tex-

ture, often not cracked at all or, when cracked, into areas ranging down to about 5 mm. in diameter. The fructifications of *P. pruinata* are much thicker than those of *P. cinerea* and darker throughout. When moistened, small pieces may be separated from the bark for sectioning.

Specimens examined:

Florida: Cocoanut Grove, *R. Thaxter, 77* (in Farlow Herb., and Mo. Bot. Gard. Herb., 43897); Otter Creek, *C. J. Humphrey, 6703* (in Humphrey Herb.); Palm Beach, *H. von Schrenk* (in Mo. Bot. Gard. Herb., 43043).

Alabama: Montgomery County, *R. P. Burke, 374* (in Mo. Bot. Gard. Herb., 57242).

Mexico: Motzorongo, near Cordoba, *W. A. & E. L. Murrill, 988* (in Mo. Bot. Gard. Herb., 54621); Orizaba, *W. A. & E. L. Murrill, 764,* in part, comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 54635).

Cuba: *C. Wright, 193,* type (in Farlow Herb., and Kew Herb.); Alto Cedro, Santiago de Cuba Province, *Earle & Murrill, 516, 518, 544, 555,* comm. by N. Y. Bot. Gard. Herb.; Ceballos, *C. J. Humphrey, 2815.*

Porto Rico: Mount Morales, near Utuado, *Mrs. E. G. Britton & D. W. Marble, 1204,* comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 61486).

Jamaica: Hope Gardens, *W. A. Murrill, 2,* comm. by N. Y. Bot. Gard. Herb.; Moneague to Union Hill, *W. A. Murrill, 1176,* comm. by N. Y. Bot. Gard. Herb.

110. P. rimosissima (B. & C.) Burt, n. comb.

Corticium rimosissimum Berkeley & Curtis, Am. Acad. Arts & Sci. Proc. **4**: 124. 1858; Sacc. Syll. Fung. **6**: 639. 1888; Massee, Linn. Soc. Bot. Jour. **27**: 122. 1890.—An *Stereum umbrinum* Berk. & Curtis?

Type: type distribution in C. Wright, Plants of U. S. North Pacific Expl. Exp., 110.

Fructifications broadly effused, rather thick, dry, membranaceous, separable in rather large pieces, pliant when dry, now bister in the herbarium, not shining, even, cracking through the colored hymenium into polygonal masses 1–4 to a mm. and

showing the underlying pale substance, the true margin unknown; in section 360–450 μ thick, colored in the hymenial layer, with the basal layer composed of obliquely ascending, loosely interwoven, thin-walled, hyaline hyphae 3–4 μ in diameter, not incrusted, not nodose septate, and of thick-walled, non-staining, hyaline organs 4½ μ in diameter, not incrusted, whose pointed tips protrude as cystidia up to 12 μ beyond the basidia; spores hyaline, even, 6 × 4½ μ—few found and may not belong.

Fragmentary fructifications not having margin are 4 cm. long, 2 cm. wide.

On dead cane. Nicaragua.

P. rimosissima is closely related in color and structure to *Stereum umbrinum* but has colorless cystidia not incrusted and only 4½–6 μ in diameter, and thinner fructifications which are not known yet to occur reflexed.

Specimens examined:

Nicaragua: *C. Wright*, type (in U. S. Dept. Agr. Herb.).

111. P. Weiri Bresadola, Mycologia **17**: 70. 1925.

Type: in Weir Herb.

Fructifications long and broadly effused, thin, closely adnate, becoming cream-buff to chamois in the herbarium, even, somewhat cracked, the margin thinning out; in section 150 μ thick, concolorous with, and giving the color to, the fructification, composed of densely interwoven, rigid, slightly colored hyphae 2–3½ μ in diameter, not incrusted; gloeocystidia flexuous or sometimes filamentous, 30–75 × 3–5 μ; cystidia not incrusted, thin-walled, cylindric, obtuse, 6–8 μ in diameter, protruding up to 40–50 μ beyond the basidia, not numerous; basidia with 4 sterigmata; spores hyaline, even, cylindric, 6–8 × 3–3½ μ, copious.

Fructifications 5–12 cm. long, 2–4 cm. wide.

On wood of decaying logs of *Pinus monticola*. Idaho. September.

The gloeocystidia of *P. Weiri* are unusual in their position, since they are occasionally oblique or parallel with the substratum, and more elongated then than when in the more usual, erect position, nor did they become visible in my sections stained with

eosin until the sections have cleared somewhat in the permanent glycerine mount. The color of the densely interwoven tissue of the fructification should aid in recognition of the species.

Specimens examined:

Idaho: Priest River, *J. R. Weir*, *23345*, type (in Weir Herb.).

112. P. Farlowii Burt, n. sp.

Type: in Burt Herb.

Fructifications effused, closely adnate, rather thick, pale olive-buff in the herbarium, even, somewhat cracked and showing the tissue to be horn-like and somewhat resin-colored (pecan-brown) where exposed on sides of the fissures, the margin thinning out, composed of finely interwoven hyphae; in section 250–350 μ thick, somewhat colored, inclosing some portions of the substratum, composed of densely interwoven and conglutinate hyphae 2–3 μ in diameter, not incrusted, not nodose-septate, indistinct; no gloeocystidia; cystidia incrusted, 30–70 × 12–15 μ, protruding up to 30 μ, few and scattered; spores hyaline, even, 4 × 2 μ.

Fructifications in fragments 2–3 cm. long, 2 cm. wide.

On very rotten frondose wood. New Hampshire. September.

P. Farlowii shows in the dried specimen a pale olive-buff hymenium covering a horn-like, somewhat resin-colored underlying layer; the cystidia are so large as to be a good distinctive character.

Specimens examined:

New Hampshire: Chocorua, Bowditch Swamp, *W. G. Farlow*, *16*, type.

113. P. colorea Burt, n. sp.

Type: in Burt Herb.

Fructifications longitudinally effused, very thin, closely adnate, light drab, not shining, even, the margin thinning out, indeterminate; in section 70–80 μ thick, light drab, 2-layered, with a layer along the substratum about 30 μ thick, of densely longitudinally interwoven, somewhat colored hyphae about 3 μ in diameter, indistinct, conglutinate, and with a colored hymenial layer of erect basidia, paraphyses, and cystidia; no gloeocystidia;

cystidia incrusted, slightly colored, fusiform, 24–33 × 12–15 μ, few, immersed in the hymenial layer; spores of a crushed preparation cylindric, hyaline, even, curved, 8–10 × 2–3 μ.

Fructifications 3–9 cm. long, 1–1½ cm. wide.

On bark of dead branches about 1–½ cm. in diameter, of frondose species. Louisiana. December.

P. colorea belongs near the *P. cinerea* group of very variable species. It may well prove that *P. colorea* is not a specifically distinct member of this group when more abundant material from southern Louisiana is available, but it seems to me distinct now by the longitudinal layer next to the substratum, light drab color throughout, few, large, slightly colored cystidia which are confined to the hymenial layer, and by the slender, elongated spores.

Specimens examined:

Louisiana: St. Martinville, *A. B. Langlois, ch*, type.

114. P. decorticans Burt, n. sp.

Type: in Burt Herb.

Fructifications long-effused, closely adnate, very thin, growing on the wood, spreading longitudinally and laterally between the wood and bark, loosening the latter, pale pinkish buff and pale gull-gray to whitish, pruinose, with occasional tubercules in some specimens; in section brownish throughout, 50–90 μ thick, not zonate, composed of densely arranged, interwoven, slightly colored, erect hyphae 3 μ in diameter, with no darker and opaque zone next to the substratum; cystidia few, incrusted, ovoid to subglobose, up to 20–25 × 15 μ, seen only in the region next to the substratum; paraphyses with slender, antler-shaped branches protrude from hymenium; spores hyaline, even, slightly curved, 8–9 × 3 μ, few seen.

Fructifications 1–2 cm. wide, 2 cm.–6 m. long, on under side of dead branches along which the loosened bark curls back laterally.

On *Quercus Garryana*, *Acer macrophyllum*, and *Rhus diversiloba*. Washington and Oregon. February to December. Common locally.

P. decorticans differs from *P. cinerea*, *P. nuda*, *P. caesia*, and *P. violaceo-livida* in not being so dark as to be opaque next to the

substratum. Its most noteworthy character, by which it may be recognized at a glance, is its curious habit of forming the fructification on bark-covered limbs between the bark and the wood, so that the loosened bark—very noticeable on *Quercus* limbs—curls back, disclosing the fructification closely adnate on the wood. The antler-shaped branching paraphyses occur in *P. phyllophida* also.

Specimens examined:

Washington: Bingen, *W. N. Suksdorf, 910*, type, *756, 757, 758.*

Oregon: Corvallis, *C. Epling* (in Mo. Bot. Gard. Herb., 60183), *S. M. Zeller, 1769, 2258* (in Mo. Bot. Gard. Herb., 56846, 63028).

115. P. nuda (Fr.) Bresadola, I. R. Accad. Agiati Atti III. **3**: 114. 1897; Bourdot & Galzin, Soc. Myc. Fr. Bul. **28**: 405. 1913; Rea, Brit. Basid. 695. 1922.

Thelephora nuda Fries. Syst. Myc. **1**: 447. 1821.—*Corticium nudum* Fries, Epicr. 564. 1838; Patouillard, Tab. Anal. Fung. **2**: 33. *f. 582.* 1887; Sacc. Syll. Fung. **6**: 626. 1888.—*Peniophora ochracea* Massee, Linn. Soc. Bot. Jour. **25**: 150. 1889, but not *Corticium ochraceum* Fries.

Illustrations: Patouillard, *loc. cit.*

Fructification effused, closely adnate, very thin, pale drab-gray, pale purplish gray or pale gull-gray, pruinose, waxy, cracking in drying; in section brownish, darker and opaque next the substratum, 75–160 μ thick, the hyphae densely interwoven, rather erect, 3 μ in diameter, somewhat colored; cystidia incrusted, in all regions of the fructification, usually about 20–25 × 6 μ, larger near the substratum and sometimes up to 15 μ in diameter; spores hyaline, even, curved, 4½–9 × 2½–3 μ, reported larger by European authors.

Fructifications 2–6 × 1–2 cm.

On fallen limbs of frondose species such as *Acer*, *Quercus*, *Populus*, etc. Canada to Texas, in Europe and Japan. April to January. Occasional.

I have seen no authentic specimens of *P. nuda*, but the European concept of this species differs from *P. cinerea* in having the fructifications more whitish gray in color, more broadly effused,

and less evidently formed by confluence of several small fructifications and with some cystidia near the substratum of greater diameter than those elsewhere. I have seen no spore collections, and it is possible that the spore measurements given above are too small, since they are based on spores found in preparations of sections.

Specimens examined:

Exsiccati: Ravenel, Fungi Am., 454, under the name *Corticium ochraceum*.

Canada: Ottawa, *J. Macoun, 26*.

Vermont: Middlebury, *E. A. Burt*.

New York: Alcove, *C. L. Shear, 1306;* Altamont, *E. A. Burt*.

New Jersey: Newfield, *J. B. Ellis* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61338).

Maryland: Takoma Park, *C. L. Shear, 1358*.

Virginia: *C. L. Shear, 1181*.

South Carolina: Pinopolis, in Ravenel, Fungi Am., 454.

Georgia: Atlanta, *E. Bartholomew, 8981* (in Mo. Bot. Gard. Herb., 63459).

Florida: Daytona, *R. A. Harper, 5* (in Mo. Bot. Gard. Herb., 54538).

Alabama: Auburn, *F. S. Earle* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 63415).

Louisiana: Baton Rouge, *C. W. Edgerton, 830*.

Texas: Beaumont, *C. J. Humphrey, 5936*.

Japan: Province Bungo, *N. Nakayma*, comm. by A. Yasuda, 125 (in Mo. Bot. Gard. Herb., 59471).

116. P. argentea Ellis & Everhart in herb., n. sp.

Type: in N. Y. Bot. Gard. Herb. and Mo. Bot. Gard. Herb.

Fructifications effused, closely adnate, thin, pallid mouse-gray to drab-gray, pruinose, cracked in drying, the margin darker and thinning out; in section brown and opaque with exception of the hyaline hymenial layer, 150 μ thick, with the hyphae densely interwoven, thick-walled, stiff, 3–3½ μ in diameter, colored as in *Hymenochaete*, not incrusted; cystidia not incrusted, partially destroyed and rendered nearly invisible by potassium hydrate solution, tapering upward to a point, protruding up to 30 μ,

6–7 μ in diameter, often colored for 20 μ at the base and there with the aspect of buried setae; basidia deteriorated; no spores found.

Fructifications 4–8 cm. long, 1–1½ cm. broad.

On bark and decorticated wood of decaying *Fraxinus*. Louisiana. January. Probably rare.

This species has the color and aspect of *P. nuda* and *P. caesia* but differs from both of these and also from *P. cinerea* in having its opaque basal layer 120 μ thick, comprising the whole thickness of the fructification except the hymenium, and in having its hyphae thick-walled and distinct and colored as in *Hymenochaete*. The cystidia differ from those of the species just named and also *P. pruinata* in not being incrusted and are noteworthy by being attacked and partially dissolved by 7 per cent solution of potassium hydrate to such a degree that they are best studied when sections are mounted in lactic acid.

Specimens examined:

Louisiana: St. Martinville, *A. B. Langlois, 1758*, type (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 63416).

117. P. violaceo-livida (Sommf.) Bresadola in Bourdot & Galzin, Soc. Myc. Fr. Bul. **28**: 405. 1913; Rea, Brit. Basid. 695. 1922.

Thelephora violaceo-livida Sommerfelt, Fl. Lapp. Suppl. 283. 1826.—*Corticium violaceo-lividum* (Sommf.) Fries, Epicr. 564. 1838; Hym. Eur. 655. 1874; Sacc. Syll. Fung. **6**: 627. 1888.

Fructifications somewhat effused, closely adnate, rather thick, tubercular, pale mouse-gray to drab-gray, often round; in section brownish, 100–300 μ thick, becoming zonate within, darker and opaque next to the substratum, the hyphae somewhat colored, densely arranged, erect; cystidia incrusted, 20–30 × 6–9 μ, distributed in all regions, very numerous; spores hyaline, even, curved, 6–9 × 2½–4 μ, as found with sections.

Fructifications 1–4 × ½–2 cm., often with the component masses rounded, 5–7 mm. in diameter.

On fallen limbs of *Salix, Prunus, Fraxinus Castanea,* and *Quercus*. Canada to Louisiana. March to October. Rare.

The concept of this species presented by Bresadola, which has

become generally accepted in Europe, is followed here except that I have referred to this species effused fructifications with tuberculate surface, thick and zonate within, as well as fructifications consisting of aggregations of small, round masses. The specimen received from Bresadola has the latter form and is on *Prunus Cerasus;* one from Romell on *Salix*, the substratum first cited for the species, has a similar zonate structure within and a tubercular surface but is more effused than that from Bresadola.

Specimens examined:

Lappland: *Sommerfelt*, authentic specimen under the name *Thelephora fallax* var. *violaceo-livida* (in Herb. Fries).

Sweden: *L. Romell, 71.*

Austria: Hall in Tirol, *V. Litschauer.*

Italy probably: locality not stated, *G. Bresadola.*

Canada: Ontario, Ottawa, *J. Macoun, 27, 131.*

Vermont: Middlebury, *E. A. Burt*, two gatherings.

Massachusetts: near Boston, *E. A. Burt.*

New Jersey: Newfield, *J. B. Ellis* (in Mo. Bot. Gard. Herb., 61339).

Maryland: Takoma Park, *C. L. Shear, 1027.*

District of Columbia: Soldiers Home, *C. L. Shear, 1116.*

Louisiana: Baton Rouge, *Edgerton & Humphrey*, comm. by C. J. Humphrey, 2521.

118. P. cinerea (Pers.) Cooke, Grevillea **8**: 20. *pl. 123, f. 8.* 1880; Sacc. Syll. Fung. **6**: 643. 1888; Bourdot & Galzin, Soc. Myc. Fr. Bul. **28**: 407. 1913; Rea, Brit. Basid., 696. 1922.

Corticium cinereum Persoon, Roemer Neues Mag. Bot. **1**: 111. 1894; Fries, Epicr. 563. 1838; Hym. Eur. 654. 1874.—*Thelephora cinerea* § *Corticium* Persoon, Syn. Fung. 579. 1801; Myc. Eur. **1**: 148. 1822; Fries, Elenchus Fung. **1**: 221. 1828.—*Kneiffia cinerea* (Fr.) Bresadola, Ann. Myc. **1**: 103. 1903.—*Corticium fumigatum* de Thümen, Torr. Bot. Club Bul. **6**: 95. 1876; Myc. Univ., 513. 1876.—*Thelephora lilacina* Schweinitz, Am. Phil. Soc. Trans. N. S. **4**: 168. 1832.—*Peniophora lilacina* (Schw.) Massee, Linn. Soc. Bot. Jour. **25**: 147. 1889.

Illustrations: Fries, Icones Hym., *pl. 198, f. 4;* Cooke, *loc. cit.;* Patouillard, Tab. Anal. Fung. *f. 251.*

Fructifications effused, closely adnate, very thin, in small patches becoming confluent, lurid, ashy in various shades as pale drab-gray, pale mouse-gray, and cinnamon-drab, pruinose, waxy, becoming cracked in drying; in section 50–100 μ thick usually, brownish, darker and opaque near the substratum, the hyphae densely interwoven, 3 μ in diameter, somewhat colored; cystidia incrusted, 25–40 $\times$ 4½–9 μ, distributed throughout the section; spores hyaline, even, cylindric, 6–9 $\times$ 2–3 μ, borne 4 to a basidium.

Fructifications 2–5 $\times$ ½–1 cm.; when scattered 2–5 mm. in diameter.

On fallen limbs of *Alnus*, *Acer*, *Prunus*, *Pyrus*, *Quercus*, and most other frondose and coniferous species. Throughout North America, West Indies, Europe, southern Africa, and Japan—probably cosmopolitan. Our commonest species. Throughout the year.

P. cinerea may be recognized by its resemblance to a thin coat of ashy gray or slightly tinted paint on the bark of fallen limbs; the substance of the sections is brownish when viewed with a hand lens, and dark and opaque next the substratum under the compound microscope. *P. caesia*, *P. nuda*, and *P. violaceo-livida* must be cautiously separated from *P. cinerea*, for all are closely related.

Specimens examined:

Exsiccati: Berkeley, Brit. Fungi, 63, 64; Ellis, N. Am. Fungi, 21, under the name *Corticium fumigatum*, 610; Ell. & Ev., Fungi Col., 610, 805, under the name *C. fumigatum;* de Thümen, Myc. Univ., 513, type distribution of *C. fumigatum*, 1206; Sydow, Myc. Germ., 205.

Sweden: *L. Romell, 69, 70.*

England: in Berkeley, Brit. Fungi, 63, 64; Kew Gardens, *E. M. Wakefield* (in Mo. Bot. Gard. Herb., 57121).

Germany: Brandenburg, in Sydow, Myc. Germ., 205; Berlin, *P. Magnus* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 55803).

Austria: Lengerich, *Brinkmann*, comm. by G. Bresadola; Tirol, three specimens, comm. by V. Litschauer.

Italy: Trento, *G. Bresadola;* Vallambrosa, *Cavara*, comm. by G. Bresadola.

Newfoundland: Bay of Islands, *A. C. Waghorne, 989* (in Mo. Bot. Gard. Herb., 5009).

Canada: *J. Macoun, 8, 9, 50.*

Quebec: Hull, *J. Macoun.*

Ontario: London, *J. Dearness, 169a, 169c* (in Mo. Bot. Gard. Herb., 11350, 5629); Ottawa, *J. Macoun, 334.*

Maine: Portage, *L. W. Riddle.*

New Hampshire: Chocorua, *W. G. Farlow, 147* (in Mo. Bot. Gard. Herb., 55262) and three specimens in Burt Herb.; North Conway, *A. S. Rhoads, 8* (in Mo. Bot. Gard. Herb., 56977), *W. H. Snell, 627* (in Mo. Bot. Gard. Herb., 59294).

Vermont: Middlebury, *E. A. Burt,* nine gatherings.

Massachusetts: Arlington, *E. A. Burt, A. P. D. Piguet,* comm. by W. G. Farlow (in Mo. Bot. Gard. Herb., 43959); Billerica, *E. A. Siegler* (in Mo. Bot. Gard. Herb., 55035); Boston, *E. A. Burt;* Stoneham, *C. L. Shear, 1239.*

Connecticut: Portland, *G. P. Clinton* (in Mo. Bot. Gard. Herb., 43945).

New York: Albany, *H. D. House* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 15955, 57517, 59673, 59690, 59695), *L. O. Overholts, 3388* (in Mo. Bot. Gard. Herb., 6989), *C. H. Peck* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 55987, 57516, 57518); Alcove, *C. L. Shear, 248, 1006, 1100, 1138, 1216, 1300;* Carrollton, *C. H. Peck* (in Mo. Bot. Gard. Herb., 56012); East Galway, *E. A. Burt;* Greenbush, *C. H. Peck* (in N. Y. State Mus. Herb., 74, and Mo. Bot. Gard. Herb., 55776); Hudson Falls, *S. H. Burnham, 19* (in Mo. Bot. Gard. Herb., 54504); Ithaca, *G. F. Atkinson, 674, 8218, H. S. Jackson,* Cornell Univ. Herb., 14394, *C. O. Smith,* comm. by G. F. Atkinson, 8223; Karner, *H. D. House* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 54369); Knox, *C. H. Peck* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 55751); Menands, *C. H. Peck* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 55805); Middle Grove, *E. A. Burt;* Van Cortland Park, New York City, *C. H. Peck* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 55977); Orient, *R. Latham, 181* (in Mo. Bot. Gard. Herb., 44227); Selkirk, *C. H. Peck* (in N. Y. State Mus. Herb., and Mo. Bot. Gard.

Herb., 55773); Van Etten, Tioga County, *W. C. Barbour, 1365* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61400); West Albany, *C. H. Peck* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 55749); Westport, *C. H. Peck* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 55750); White Plains, *L. M. Underwood* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61588); Willsboro Point, *C. O. Smith;* West Fort Ann, *S. H. Burnham, 17* (in Mo. Bot. Gard. Herb., 44046).

New Jersey: Newark, *H. S. Jackson;* Newfield, *J. B. Ellis* (in Mo. Bot. Gard. Herb., 4818), *1076, 1078,* comm. by W. G. Farlow (in Mo. Bot. Gard. Herb., 14762, 7459), comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 61448), in Ellis, N. Am. Fungi, 21, 610, in Ell. & Ev., Fungi Col., 610, 805, and de Thümen, Myc. Univ., 513, 1206; Belleplain, *C. L. Shear, 1165.*

Pennsylvania: Bethlehem, *Schweinitz,* type of *Thelephora lilacina* (in Farlow Herb. and Kew Herb.).

Maryland: Takoma Park, *C. L. Shear, 962, 1028, 1076, 1162, 1349.*

District of Columbia: Takoma Park, *C. L. Shear, 515* (in N. Y. State Mus. Herb., and Mo. Bot. Gard. Herb., 55808), *1353;* Washington, *C. L. Shear, 1200, 1258.*

Virginia: Park Lane, *W. H. Long, 18509* (in Mo. Bot. Gard. Herb., 55061).

North Carolina: Blowing Rock, *G. F. Atkinson, 4328, 8030.*

Georgia: Atlanta, *E. Bartholomew, 5676* (in Mo. Bot. Gard. Herb., 44252).

Florida: New Smyrna, *W. A. Murrill, 5,* comm. by N. Y. Bot. Gard. Herb. (in Mo. Bot. Gard. Herb., 62085).

Alabama: Auburn, *F. S. Earle,* unnumbered specimens and *42* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61399, 61452), and *F. S. Earle & C. F. Baker* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61428); Montgomery and Montgomery County, *R. P. Burke, 9, 11, 42, 120, 449, 455, 458, 461, 469, 513, 818* (in Mo. Bot. Gard. Herb., 16360, 22340, 21100, 19555, 57277, 57280, 57283, 57288, 57303, 63117).

Louisiana: Baton Rouge, *Edgerton & Humphrey, 5727a, 5666.*

Tennessee: *J. R. Weir, 7558* (in Mo. Bot. Gard. Herb., 55464).

Ohio: Norwood, *C. G. Lloyd, 1576.*

Indiana: Crawfordsville, *A. R. Bechtel, 12* (in Mo. Bot. Gard. Herb., 59660); Millers, *E. T. & S. A. Harper, 939.*

Illinois: Barry, *H. W. Anderson* (in Mo. Bot. Gard. Herb., 55966); Cypress, *C. J. Humphrey, 1359* (in Mo. Bot. Gard. Herb., 22522); River Forest, *E. T. & S. A. Harper, 676, 757;* Riverside, *E. T. & S. A. Harper, 677.*

Michigan: Ann Arbor, *C. H. Kauffman* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 61396); Gogebic County, *E. A. Bessey, 56, 78, 183, 216, 236, 371* (in Mo. Bot. Gard. Herb., 56545, 56549, 56580, 56546, 56590, 56635); Michigan Agricultural College, *B. O. Longyear* (in Mo. Bot. Gard. Herb., 55704); New Richmond, *E. W. Hartwell* (in Mo. Bot. Gard. Herb., 58163); Vermilion, *A. H. W. Povah, 242* (in Mo. Bot. Gard. Herb., 58163).

Wisconsin: Blue Mounds, comm. by Univ. Wis. Herb., 28; Madison, *E. Bartholomew 6652* (in Mo. Bot. Gard. Herb., 57039), *M. C. Jensen*, comm. by C. J. Humphrey, 2432 (in Mo. Bot. Gard. Herb., 4835), and *W. Trelease* (in Mo. Bot. Gard. Herb., 4816, 43988, 43989).

Minnesota: Lake Itaska, *E. L. Jensen, 5* (in Mo. Bot. Gard. Herb., 12530); Univ. Farm Campus, St. Paul, *E. L. Jensen, 3* (in Mo. Bot. Gard. Herb., 4203).

Missouri: Columbia, *B. M. Duggar, 572, 574;* Creve Coeur Lake, *L. O. Overholts, 3159* (in Mo. Bot. Gard. Herb., 5714).

Nebraska: Lincoln, *C. L. Shear, 1054, 1058, 1342.*

Colorado: Golden, *E. Bethel & L. O. Overholts, 1744* (in Mo. Bot. Gard. Herb., 54870).

Manitoba: Winnipeg, *A. H. R. Buller*, comm. by G. R. Bisby, 878, and *G. R. Bisby, 1348* (in Mo. Bot. Gard. Herb., 58995, and 60554 respectively).

British Columbia: Salmo, *J. R. Weir, 444* (in Mo. Bot. Gard. Herb., 6243); Sidney, *J. Macoun, 6, 775* (in Mo. Bot. Gard. Herb., 5765, 55324).

Washington: Bingen, *W. N. Suksdorf, 700, 701, 721, 744, 759, 861, 885, 918, 954, 960, 963;* Corvallis, *S. M. Zeller, 2262* (in Mo. Bot. Gard. Herb., 63033); Chelan, *J. R. Weir, 5490* (in Mo. Bot. Gard. Herb., 58260); Kalama, *C. J. Humphrey, 6219;*

Washougal, *R. H. Turk*, comm. by S. M. Zeller, 2630 (in Mo. Bot. Gard. Herb., 63057).

California: Berkeley, comm. by W. A. Setchell, 1032 (in Mo. Bot. Gard. Herb., 44241); Stanford University, *C. F. Baker, 12;* Sierra Nevada Mountains, *W. H. Harkness, 1025* (in Kew Herb., under the name *Peniophora carnea* Berk. & Cke.).

Mexico: Guernavaca, *W. A. & E. L. Murrill, 358, 407* (in N. Y. Bot. Gard. Herb., and Mo. Bot. Gard. Herb., 54470, 54532).

Cuba: San Antonio de los Baños, Havana Province, *Earle & Murrill, 73,* comm. by N. Y. Bot. Gard. Herb.

Porto Rico: Rio Piedras, *J. A. Stevenson, 2451, 2920, 3067, 5581, 5638* (in Mo. Bot. Gard. Herb., 9185, 3125, 9055, 6957, 54585).

Jamaica: Chester Vale, *W. A. & E. L. Murrill, 334,* comm. by N. Y. Bot. Gard. Herb.; Cinchona, *W. A. & E. L. Murrill, 596,* comm. by N. Y. Bot. Gard. Herb.; Troy and Tyre, *W. A. & E. L. Murrill, 894,* comm. by N. Y. Bot. Gard. Herb.

Africa: Stellenbosch, Cape Colony, *P. A. van der Bijl, 326* (in Mo. Bot. Gard. Herb., 63397).

Japan: Mt. Mikuma, Province Awaji, *A. Yasuda, 4* (in Mo. Bot. Gard. Herb., 55666).

119. P. caesia Bresadola in Bourdot & Galzin, Soc. Myc. Fr. Bul. **28**: 406. 1913; Rea, Brit. Basid., 695. 1922.

Corticium caesium Bresadola, Fungi Trid. **2**: 39. *pl. 145, f. 2.* 1892; Sacc. Syll. Fung. **11**: 126. 1895.

Illustrations: Bresadola, *loc. cit.*

Type: authentic specimen in Burt Herbarium.

Fructifications broadly effused, closely adnate, very thin, pale mouse-gray to pale purplish-gray, delicately pruinose, cracked in drying, the margin similar; in section brownish, 40–90 μ thick, dark and opaque next to substratum; hyphae densely interwoven, somewhat colored; cystidia near the substratum 15–25 × 10–20 μ, incrusted, becoming slightly colored, not numerous; spores hyaline, even, curved, 6–8 × 2½–3 μ as found in preparations of sections, probably larger in spore falls.

Fructifications 2–10 × 1–2 cm.

On fallen limbs of *Syringa*, *Betula*, *Quercus*, and other frondose

species. Vermont to District of Columbia, in Missouri, and in Europe. March to December. Rare.

P. caesia is more widely effused than *P. cinerea,* is not formed by confluence of many small fructifications, and has much the color and aspect of *P. nuda* but differs from the latter in absence of the numerous, small cystidia.

Specimens examined:

Exsiccati: Roumeguère, Fungi Gallici, 2910, under the name *Corticium incarnatum,* 3213, under the name *Corticium cinereum.*

Austria: Vienna, comm. by V. Litschauer.

Italy: Trient, *G. Bresadola,* authentic specimen.

France: in Roumeguère, Fungi Gallici, 2910, 3213.

Vermont: Lake Dunmore, *E. A. Burt.*

District of Columbia: Washington, Department Grounds, on *Syringa vulgaris, C. L. Shear, 1264,* in part, and an unnumbered specimen.

Missouri: Columbia, *B. M. Duggar, 448.*

120. P. carnea (Berk. & Cooke) Cooke, Grevillea **8:** 21. *pl. 124, f. 11.* 1879; Sacc. Syll. Fung. **6:** 644. 1888; Massee, Linn. Soc. Bot. Jour. **25:** 151. 1889.

Corticium carneum Berkeley & Cooke, New York Acad. Sci. Ann. **1:** 179. 1878; Linn. Soc. Bot. Jour. **17:** 141. 1878.

Type: in Kew Herb.

Fructification effused, closely adnate, thin, ochraceous flesh-color, drying avellaneous and cracked, the margin whitish and fibrillose; in section brownish, 100–120 μ thick, with a dark, semi-opaque zone next to the substratum; hyphae densely interwoven, 3–3½ μ in diameter, slightly colored, somewhat longitudinally interwoven next to the substratum; cystidia incrusted, of two kinds—very large cystidia resembling conical or subglobose crystalline masses 45–75 × 30–75 μ are seated on the opaque zone, other cystidia 25–35 × 6–8 μ are scattered throughout the region between the dark zone and the surface of the hymenium; gloeocystidia flexuous, 40–50 × 4–4½ μ, not numerous; spores hyaline, even, slightly curved, 8–12 × 3–4 μ.

Fructifications 1–6 cm. long, ½–2 cm. broad.

On logs and fallen, decaying, frondose limbs. Texas and Cuba. March. Rare.

The thin, closely adnate fructifications of *P. carnea*, brownish within and with a broad, dark, opaque zone next to the substratum, place this species in the *P. cinerea* group. It is remarkable by having, in addition to the ordinary kind of cystidia, very much larger cystidia which finally become, by the accretions of mineral matter, very large masses of mineral nature with very coarse grains on the exterior of the mass. In the Cuban gathering which I have referred to this species, when a small portion of the hymenial surface was moistened with alcohol and then with water preparatory to removal of a bit of the fructification for sectioning, the moist hymenium became punctate with minute depressions, probably by presence at those points of the large buried cystidia. This may prove a useful test for preliminary sorting out, without examination by the microscope, of the rare *P. carnea* from the more common *P. cinerea* of nearly similar aspect. *P. heterocystidia* has cystidia of two kinds, like those of *P. carnea* but thicker, readily separable from the substratum when moistened, and with a narrow brown zone in the middle of its sectional preparations and with a loosely interwoven hyaline zone next to the substratum. The specimen in Kew Herbarium, collected on fir in the Sierra Nevada Mountains, California, by Harkness, 1025, and referred by Cooke to *P. cinerea* does not have the large cystidia of his type and is *P. cinerea* instead.

Specimens examined:

Texas: Galveston Bay, *H. W. Ravenel, 78,* type (in Kew Herb.).

Cuba: San Diego de los Baños, Pinar del Rio Province, *Earle & Murrill, 333,* comm. by N. Y. Bot. Gard. Herb.

SPECIES TOO INCOMPLETELY DESCRIBED FOR LOCATION AMONG PRECEDING SPECIES

Peniophora convolvens Bresadola, Ann. Myc. **18:** 48. 1920.

"Elongato-effusa, ceraceo-membranacea, pallida vel avellanea, ambitu similari, demum libero-convoluto; hymenio demum late rimoso, interstitiis fibrillosis; sporis hyalinis, obovatis, 6–7 × 5–6 μ; basidiis clavatis, 40–45 × 6–7 μ; cystidiis saepe immersis vel usque ad 45 μ prominentibus, 9–12 μ crassis.

"Hab. ad ligna, St. Croix, Americae centralis. *Raunkiaer.*"

P. gigaspora Massee, Linn. Soc. Bot. Jour. **25**: 152. 1889; Sacc. Syll. Fung. **9**: 238. 1891.

"Latissime effusa, ambitu fimbriata albicans; hymenio pallido, velutino, sicco indurato, contiguo; cystidia fusoidea, 80–120 × 30–40 μ; sporae oblongo-ellipsoideae, 18–20 × 10 μ.

"N. Providence, Bahamas.

"On decorticated wood, forming thin, continuous, broadly effused patches, somewhat resembling *P. velutina*, but differing in cystidia and spores."

(*To be concluded*)

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THE EFFECT OF TREATING THE VIRUS OF TOBACCO MOSAIC WITH THE JUICES OF VARIOUS PLANTS

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During the period that the mosaic disease of tobacco has been under investigation in this laboratory, many attempts have been made to transfer the disease, through cross inoculation, to the pokeweed, *Phytolacca decandra.* Five operators have at different times endeavored to make the transfers referred to, each employing a somewhat different technique. In no instances have results been obtained that might be interpreted as a positive indication of the susceptibility of the pokeweed to the tobacco form of mosaic.

Although at that time no experiment had been made here in the direction of testing the possibility of transfer through insect agency, it seemed quite probable that the pokeweed might be immune. It occurred to the junior author that it might be of interest to determine the effect of the juice of the pokeweed on the tobacco virus. Accordingly, a preliminary experiment was arranged, and it was determined to include in this the effect upon the tobacco mosaic agency of both the juice from healthy pokeweed and that from pokeweed affected with the mosaic peculiar to that host.

Juice or crude sap was then prepared from (1) healthy pokeweed, (2) pokeweed affected with mosaic, and (3) tobacco plants

affected with tobacco mosaic. In each case the procedure was as follows: The younger shoots and leaves were ground up in a meat or food grinder and the resulting semi-fluid mass was thrown into a muslin bag and the juice pressed out. The juice was then filtered through absorbent cotton. The undiluted filtered juice was then used as indicated later. Adequate precautions were taken as to the cleanliness of all vessels involved. The meat grinder and other articles required were, after preliminary cleaning, soaked several hours in hot water containing ½ per cent formaldehyde, and afterwards boiled in plain water. In these and in later experiments where pipettes and other glassware were required, such vessels were invariably dry-sterilized.

In the preliminary experiment, 1 part of the tobacco juice from diseased plants was mixed with 99 parts of each of the 2 types of pokeweed juice, and as a partial control on the dilution and the infectivity of the virus, 1 part of the same diseased tobacco juice was added to 99 parts of sterile distilled water. Further control was not used at the time owing to a scarcity of suitable plants for the inoculation work. The fluids as diluted for inoculation were permitted to stand 3–4 hours prior to their use. The technique of inoculation is described later. Twenty healthy young tobacco plants were inoculated with each of the 3 lots of material, 4 cc. of inoculum being used for each lot. The inoculations were made June 12, and all of the 20 control plants (diseased juice 1 part, water 99 parts) were diseased by June 23, while none of the 40 plants inoculated with the diseased tobacco juice made up in pokeweed juice showed the least indication of mosaic on June 30, when the experiment was closed. These results were so definite that it was determined to repeat the work and to use a variety of plant juices when opportunity offered.

The method of inoculation employed in the preliminary experiments and in that subsequently reported is one that has been adopted as a standard in this laboratory and it requires a brief description. It is preferred to employ young plants with stems about 2 inches high. When possible, the plants to be inoculated are arranged in place about 1 week in advance so that sporadic occurrences of the disease may be promptly detected. Three inoculations are made in each plant, 1 on the stem near the ground,

another farther up and in a leaf axil—so as to reach the young bud—and the other in the immediate region of the terminal bud. The quantity of inoculum required is about 2 cc. for each 10 plants. A large drop of the inoculum may be placed with a glass rod on the spot desired, and with a small inoculating needle many pricks are made through this, thus working the fluid into the tissue. Before passing to the next plant the needle is flamed, then dipped in alcohol, and burned off. The usual precaution is taken with respect to touching plants, or if plants must be touched, the hands are cleansed between operations. Because no disease has appeared in any lot of plants, it is not safe to assume freedom from disease, so that every plant in any lot is treated as though it might convey disease. Inoculated plants are kept under observation for 28–30 days in all cases where more than preliminary data are required.

Preparing the crude sap as already described, experiments were arranged with shoots and leaves of pokeweed, Jimson weed (*Datura Stramonium*), geranium (*Pelargonium* sp.), cotton, and squash, with Irish potato tubers, sweet-potatoes, and apples of the variety Ben Davis. In each case the juice from diseased tobacco plants was diluted, as shown in table I, with the juice from the plant the influence of which was to be tested. In these experiments, the mixed juices were allowed to remain at room temperature about 2 hours, and then placed in a refrigerator, at 3° C., until used the following morning (15–18 hrs.). The undiluted juices used as control were similarly exposed.

From the table it is again clear that pokeweed juice effectively inactivates the agency of tobacco mosaic in a relatively short time. Even when the virus is diluted only 5 times with the pokeweed juice the inhibition is complete. Inactivation is shown by the juice of Jimson weed when the latter is in relatively high concentration, and the juice of the geranium is also to some extent effective. On the other hand, cotton, squash, potato, sweet-potato, and apple exert no injurious influence at the concentrations tested.

It became of much interest to determine if the influence of pokeweed juice especially might result from some relatively simple chemical factor, or if it might be far more complex, possibly

analogous to agglutination. The possibility that the reaction of the juice might be an important factor suggested itself, but colorimetric tests made it clear that the H-ion concentration was

TABLE I

EFFECT OF VARIOUS PLANT JUICES ON THE PATHOGENICITY OF THE TOBACCO MOSAIC VIRUS. TEN PLANTS WERE INOCULATED IN EACH CASE

Juices constituting inoculum	Dilution	Number diseased
Diseased tobacco, dist. water	1 : 10	All (in 15 days)
Diseased tobacco, dist. water	1 : 100	All (in 11 days)
Diseased tobacco, pokeweed	1 : 5	None
Diseased tobacco, pokeweed	1 : 10	None
Diseased tobacco, pokeweed	1 : 25	None
Diseased tobacco, pokeweed	1 : 50	None
Diseased tobacco, pokeweed	1 : 75	None
Diseased tobacco, pokeweed	1 : 100	None
Pokeweed	None	1 (after 4 wks.) (apparently accidental)
Diseased tobacco, Jimson	1 : 10	All (in 9 days)
Diseased tobacco, Jimson	1 : 100	None
Jimson	None	None
Diseased tobacco, Irish potato	1 : 10	All (in 9 days)
Diseased tobacco, Irish potato	1 : 100	All (in 9 days)
Irish potato	None	None
Diseased tobacco, sweet-potato	1 : 10	All (in 11 days)
Diseased tobacco, sweet-potato	1 : 100	9
Sweet potato	None	None
Diseased tobacco, geranium	1 : 10	8 (in 15 days)
Diseased tobacco, geranium	1 : 100	3
Geranium	None	None
Diseased tobacco, apple	1 : 10	All (in 14 days)
Diseased tobacco, apple	1 : 100	8 (in 15 days)
Apple	None	None
Diseased tobacco, tobacco	1 : 10	All (in 12 days)
Diseased tobacco, tobacco	1 : 100	All (in 12 days)
Healthy tobacco	None	None
Diseased tobacco, cotton	1 : 10	All (in 13 days)
Diseased tobacco, cotton	1 : 100	All (in 13 days)
Diseased tobacco, squash	1 : 10	All (in 9 days)
Diseased tobacco, squash	1 : 100	All (in 9 days)
Squash	None	None

higher in the apple juice than in any other tested, and this last exerted no injurious influence.[1] Moreover, experiments then in progress, to be reported elsewhere, indicated a relatively high tolerance of the mosaic virus towards acids. In view of the following facts, namely, that pokeweed is a host for a form of mosaic, that Jimson weed is credited with several forms of mosaic, and

[1] Employing electrometric methods, a subsequent test made by Mr. E. R. Ranker and Miss Fanny Fern Smith gave a P_H of approximately 6.0 for the juice of the pokeweed used.

that even geranium exhibits a disease tentatively classed as a mosaic, the influence of the juices of these plants must be regarded as specific with reference to the tobacco mosaic agency. However, in order to determine if pokeweed juice possesses general germicidal properties, cultures in small Erlenmeyer flasks were arranged with sterile and unsterile (natural) juice, and both lots were inoculated with *Aspergillus niger*. The fungus grew promptly and profusely on both lots, indicating no general inhibiting effect.

The toxicity of pokeweed juice was further tested, using as an indicator the growth of *Bacterium prodigiosum* Lehm. & Neum. In carrying out the experiments with this organism a strong bacterial emulsion was prepared from a fresh nutrient agar slant culture. This emulsion was then added to pokeweed juice,[1] or to an equal quantity of distilled water, as control. These mixtures were allowed to stand for 2 hours, after which suitable dilutions were prepared and plates were poured. Every possible care was taken with the samples employed in the preparation of the dilution cultures to take the sample from the vessel in such manner that the pipette did not come in contact with the walls of the vessel where organisms might occur which had not had free access to the fluid used. In the first series of cultures the original bacterial emulsion was diluted (1) 1:5 with pokeweed juice; (2) 1:25 with pokeweed juice; and (3), for control, 1:25 with distilled water. The results are given in detail in table II.

The result of the foregoing test is convincing proof that no toxicity of pokeweed juice is exhibited toward this species of bacteria. In explanation of the table it should be pointed out that the data with the 2 dilutions of pokeweed juice are closely comparable, while the result from dilution with distilled water shows apparently a very much smaller number of bacteria present. This, however, was anticipated and is in harmony with results obtained from a preliminary series not here reported in detail. This preliminary series brought out the fact that, on

[1] The pokeweed juice used in these experiments was prepared as previously described except that in this case, in order to minimize contaminations, the pokeweed leaves and shoots were first treated for 4 hours with 20 per cent Javel water, after which they were washed in sterile distilled water.

TABLE II

EFFECT OF POKEWEED JUICE ON BACTERIUM PRODIGIOSUM; EXPOSURE TO JUICE 2 HOURS

Treatment	Plate dilution	No. colonies, 4 days	Average, colonies per cc.
Bacterial emulsion diluted 1 : 5 with pokeweed juice	1/10 1/100 1/1000 1/10000	Numerous 768 39 4	51,930
Bacterial emulsion diluted 1 :25 with pokeweed juice	1/10 1/100 1/1000	960 108 12	10,800
Bacterial emulsion diluted 1 : 25 with distilled water	1/10 1/100 1/1000	71 14 0	1,055

standing, an emulsion of this bacterium in distilled water shows an apparent decrease in the number of organisms. It is not the purpose of this paper to determine the cause of this decrease though it may be a simple aggregation phenomenon. For verification of this observation another experiment was carried out, the results of which are briefly given in table III. In this experiment the bacterial emulsion was diluted, as will be seen, with distilled water and with pokeweed juice to the same extent. Plates were poured immediately after the bacterial emulsions were diluted, and then after intervals of 1 and 2 hours respectively.

TABLE III

BACTERIUM PRODIGIOSUM IN DISTILLED WATER AND IN POKEWEED JUICE

Treatment	No. colonies, initial	No. colonies, after exposure of 1 hour	No. colonies, after exposure of 2 hours
Bacterial emulsion diluted 1 : 25, distilled water	20,300	——	7,050
Bacterial emulsion diluted 1 : 25, pokeweed juice	29,850	44,050	42,500

No discussion of table III is required further than to point out again the diminution, on standing, of the number of colonies in the case of the emulsion diluted with distilled water. The figures for the emulsion diluted with pokeweed juice are sufficiently comparable when it is recalled that this is not filtered juice, and

accordingly represents a minute suspension, in itself a sufficient cause for some variation in numbers.

These experiments were further suggestive of a specific inactivating effect of the pokeweed juice towards the agency of mosaic disease. The cases of geranium and of Jimson weed have not been more closely analyzed.

It seemed desirable to determine the possible relation of the larger colloidal particles in the pokeweed juice to inactivation, but up to the present only a few preliminary experiments have been made. These, however, are not without suggestion. Pokeweed juice was filtered through a cylindrical, porcelain atmometer cup under a pressure of one-half atmosphere, and the filtrate thus obtained was used in treating the mosaic virus subsequently used in inoculations, as in table I. When the relation of virus to filtrate was 1 : 10, the incidence of infection was 9 out of 10 plants inoculated; when the relation was 1 : 100, the virus was completely inactivated. Filtration through such a filter seems therefore to reduce the effect of the juice. It may be stated that the filter employed permits the mosaic virus to pass through but does not permit *Bacterium prodigiosum*.

Some of the same lot of pokeweed juice was diluted with an equal quantity of distilled water and then centrifuged for 30 minutes at 1500 revolutions per minute. The effect of the supernatant liquid on the virus was determined, as before, by inoculating 10 tobacco plants. With the relation of the diseased juice to this diluted liquid 1:10, 2 plants developed the disease, again indicating some loss of inactivation capacity.

It seemed conceivable that inactivation of the mosaic virus might be due to adsorption. It was not possible to determine this merely by increasing relatively the quantity of diseased tobacco juice, since this dilutes the pokeweed juice. Concentration of the diseased tobacco juice by evaporation would also be subject to criticism from another angle. Further work on the chemical or physical nature of this inactivation is planned.

For the moment the data in the 3 experiments given in table IV show further the influence of the ratio of diseased juice to pokeweed juice as developed through infection experiments, and thus supplement table I. The experiments were made under con-

ditions similar to those reported in table I, but at a different time. The progressive increase in the incidence of disease with the increasing amount of virus locates rather definitely, in conjunction with the data of table I, the inactivation capacity of the pokeweed juice.

TABLE IV

Juices constituting inoculum	Dilution	Result
Diseased tobacco, pokeweed	1 : 1	2 diseased (in 8 days)
Diseased tobacco, pokeweed	5 : 1	8 diseased (in 14 days)
Diseased tobacco, pokeweed	10 : 1	9 diseased (in 9 days)

Upon the completion of the experiments with pokeweed juice reported in table I, the results were regarded, and apparently properly so, as a simple case of inactivation. Nevertheless, it was considered desirable to ascertain if in the plants used in experiments 3–8 inclusive there might exist such a mild form of the disease as to be essentially without external symptoms. Accordingly, leaves of these plants were used directly in the inoculation of fresh young tobacco plants, but without visible result. Likewise, one-half (5) of each lot of plants used in experiments 3–8, table I, were inoculated with diseased tobacco juice, untreated, and the entire lot of 30 plants exhibited the characteristic mosaic symptoms in less than 15 days, indicating, as anticipated, not the least suggestion of a modification of susceptibility to mosaic.

The specific nature of this inactivation of the tobacco mosaic virus, especially by pokeweed juice, has seemed of sufficient importance to justify the projection of further experiments in the direction of ascertaining the physical and chemical properties of this juice.

DETERMINATION OF TOTAL NITROGEN IN PLANTS AND PLANT SOLUTIONS: A COMPARISON OF METHODS WITH MODIFICATIONS

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The analyst who has had considerable experience in the determination of nitrogen is impressed by the fact that some substances are analyzed with more ease and accuracy than other substances. Many factors are involved, not the least of which is the combination of the various forms of nitrogen in the sample to be analyzed. For example, if we consider the determination of total nitrogen in whole plants (peas, wheat, barley, etc.) including the residual nutrient solutions in which they grew, amino-, amide-, and some ammonia-nitrogen are present in the plants in addition to nitrate- and possibly ammonia-nitrogen in the residual solutions. In such a case the determination of total nitrogen presents problems that challenge the accuracy of the various methods used.

Two methods are used generally: (1) some modification of the Devarda method, and (2) the official salicylic-thiosulphate method (Assoc. Off. Agr. Chemists, '21, p. 8; I, 28). The latter method has been criticized severely by several investigators whose data have been interpreted as indicating the limitations and defects of any method based on the reduction of nitrates in acid medium. Further reference will be made to these criticisms after the presentation of data. On the other hand, the Devarda method for total nitrogen in the presence of organic matter is time-consuming, since (1) there is a preliminary alkaline distillation with the alloy to collect the ammonia obtained from the reduction of the nitrates and other substances acted upon in the process (Allen, '15; Davisson, '18), and (2) the organic matter and remaining nitrogen must be subjected to a Kjeldahl digestion followed by a second distillation into the same or a second lot of standard acid. Unfortunately, then, neither of these methods is entirely satisfactory for the determination of total nitrogen in plants and plant solutions when the two are present in the same sample.

In a study of nitrogen fixation by higher plants the total nitrogen content of the plants and residual nutrient solutions was

determined. The official salicylic-thiosulphate method was used. Extremely inaccurate results were obtained. From nutrient solutions containing respectively 400, 300, 200, 100, 50, 25, and 10 mgs. of nitrogen per 950 cc., only 68, 67, 30, 62, 62, 54, and 27 per cent of the nitrogen was recovered. From solutions containing smaller quantities of nitrogen than 10 mgs. the amounts recovered were usually less than for the blank, that is, there was a loss of nitrogen from the reagents used. A total of about 60 determinations was made, and there was no agreement among the results obtained. The greatest losses of nitrogen occurred from those samples containing whole plants in addition to the residual nutrient solutions. In several cases there was a visible evolution of nitrogen dioxide fumes, and duplicate determinations varied widely. These data tend to corroborate the statements of those investigators who have criticized the official salicylic-thiosulphate method.

In spite of these criticisms, however, it was thought advisable to attempt some modifications that might overcome the difficulties encountered. Several possibilities were tried, and from the results of these tests it was tentatively determined that the inaccuracy of the method was due, primarily, to the presence of water at some stage during the process of acid digestion. Certain details of manipulation seemed to influence the determination to a limited degree.

A modification of the official method was devised, and its accuracy for the determination of total nitrogen was tested out on the various forms of nitrogen. For purposes of comparison, simultaneous determinations on samples from the same stock, measured by the same pipettes and at the same temperature, were made by a modification of the Devarda method. The procedure for this comparison method was as follows: (The procedure for the modified official method will be given later.)

I. *If organic matter is not present.*—Place the sample in an 800-cc. Kjeldahl flask; add 1.0 gm. of Devarda alloy for every 60–70 mgs. of nitrate-nitrogen present[1]; add a small piece of paraffin; make up to

[1] Subsequent to this investigation the work of Burrell and Phillips ('25) has been published. These investigators used 1 gm. of alloy; they were dealing with small amounts of nitrogen and evidently did not determine the limits of their method. The reduction limits of 1 gm. of alloy is approximately 70 mgs. of nitrogen in the form of nitrate-nitrogen.

a total volume of 150 cc.; add 6 cc. of 10 per cent sodium hydroxide; connect to the distillation apparatus and distill into standard acid at slow boiling for 1 hour. Titrate the standard acid to neutrality.

II. *If organic matter is present.*—Proceed as in I; continue distillation to as low a volume as is safe; disconnect. Add 45 cc. of concentrated suphuric acid and 10 gms. of anhydrous sodium sulphate; digest for 1 hour after the copper color appears (the mixture remains milky due to aluminum and zinc precipitates); cool; make up to an estimated volume of 400 cc. and distill as for the modified official method.

All the determinations reported were made of the following forms of nitrogen:

1. Nitrate-nitrogen as $NaNO_3$ which was twice recrystallized from Merck's blue-label grade. The solution used was such that 1 cc. was equivalent to 1 mg. of nitrogen.

2. Ammonia-nitrogen as $(NH_4)_2SO_4$ which was recrystallized from Merck's blue-label grade. The solution used was such that 1 cc. was equivalent to 1 mg. of nitrogen.

3. Amino-nitrogen as glycine, an Eastman Kodak Company product. The solution used was such that 1 cc. was equivalent to 0.91 mg. of nitrogen.

4. Amide-nitrogen and amino-nitrogen as asparagine, a Merck product. The solution used was such that 1 cc. was equivalent to 0.95 mg. of nitrogen.

5. Total organic plant nitrogen as found in 6-day-old wheat seedlings; 10 such seedlings produced 7 mgs. of nitrogen with but little variation from this average. It would have been somewhat more accurate had smaller seeds been used, in which case the larger number used would have appreciably decreased the variation from the average.

The acid and alkali used in titration were standardized against benzoic acid obtained from the U. S. Bureau of Standards (sample No. 39B). A total of 190 determinations, including the preliminaries, was made. The results obtained were subjected to a statistical analysis, the data of which, expressed as average percentages, are given in table I. The probable error of the arithmetical mean was calculated by the formula

$$\left(E_m = \frac{0.6745\sigma}{\sqrt{n}}\right).$$

TABLE I

RECOVERY OF TOTAL NITROGEN

(average percentages and probable error)

Sample determined	Recovery by Devarda method		Recovery by modified method		No. of trials
	Sample first evptd. to dryns.	Sample plus water	Sample first evptd. to dryns.	Sample plus water	
50 mgs. nitrate-N.	97.7 ±.19	98.4 ±.03	100.4 ±.06	62.2 ±.38	8
100 mgs. nitrate-N.	68.5*	72.4* 99.9‡ ±.24	99.2 ±.10	17.8 ±.81	13 3
50 mgs. nitrate-N. 10 mgs. ammonia-N.	98.5 ±.23	99.4 ±.22	98.0 ±.06	36.7 ±1.80	12
50 mgs. nitrate-N. 10 mgs. amino-N.	97.7 ±.14	99.4 ±.04	99.3 ±.14	51.7 ±4.03	12
50 mgs. nitrate-N. 10 mgs. {amino-N. amide-N.	97.5 ±.09	96.3 ±.10	99.3 ±.28	47.6 ±.29	15
50 mgs. nitrate-N. 7 mgs. plant-N.†	99.6 ±.09	98.8 ±.09	100.2 ±.32	64.6 ±.23	12
50 mgs. nitrate-N. 7 mgs. plant-N.† 0.5 cc. H_2SO_4	These samples were not determined, as during evaporation heavy NO_2 fumes were given off.				
50 mgs. nitrate-N. 7 mgs. plant-N.†‖	100.3 ±.56		99.7 ±.69		14
50 mgs. nitrate-N. 7 mgs. plant-N.† 1 cc. N/10 NaOH	99.2 ±.52		99.1 ±.62		6
50 mgs. nitrate-N. 0.5 gm. sucrose	98.1 ±.64	99.5 ±.00	92.7 ±.90	33.2	10

* 1.0 gm. of Devarda alloy used.

† Supplied as the nitrogen content of ten 6-day-old wheat seedlings.

‡ 2.0 gms. of Devarda alloy used.

‖ This solution was adjusted to neutrality prior to determination.

From a study of the data of table I certain facts are evident:

1. The presence of free water in the sample is the determining factor for the accuracy of a method dependent upon the reduction of nitrates in acid medium (the minimum amounts of water that may be present and not decrease the accuracy of such a method

have not been determined—it is recommended, however, that no more than just a trace of free water be present).

2. When the sample is practically dry the official method as here modified is somewhat more accurate for the determination of total nitrogen than the Devarda method used.

3. The modified method is accurate for the determination of amino-, amide-, ammonia-, nitrate-, and total plant-nitrogen and combinations of these forms of nitrogen in plants and plant solutions.

4. If sugar is present in abundance a slight loss of nitrate-nitrogen may occur, due to the reducing action of the sugar. This loss would be very slight in actual practice since the nitrate-nitrogen content of plants is small.

The procedure for the modified official method as used in this investigation is as follows:

Place the sample in an 800-cc. Kjeldahl flask; adjust to neutrality or make slightly alkaline; if water is present evaporate *just to* dryness on a water bath under vacuum. Add 35–40 cc. of salicylic acid mixture (1.0 gm. of salicylic acid to 30 cc. of concentrated nitrogen-free sulphuric acid); mix thoroughly and allow to stand for at least an hour with occasional shaking (if organic matter is present, stopper tightly with a rubber cork and allow to stand over night). Add 5 gms. of sodium thiosulphate and heat for 5 minutes with a low flame; cool; add 7–10 gms. of anhydrous sodium sulphate and a pinch of copper sulphate. Digest for an hour at the boiling point after the solution clears; just before the solution solidifies dilute to an estimated volume of 400 cc.; cool completely. Add a small piece of paraffin, 100 cc. of a saturated solution of sodium hydroxide, and a piece of mossy zinc; connect immediately to the distillation apparatus and distill 150–200 cc. over into standard acid during a period of 1 hour. Titrate the standard acid to neutrality with standard alkali and calculate the amount of nitrogen present.

Subsequent to this investigation 380 determinations were made by the above method with an accuracy equivalent to that here reported. Some of the samples determined had a total nitrogen content as high as 400 mgs., in which case the amount of salicylic acid mixture was increased to 45 cc. Some of the samples determined had a total nitrogen content of 2 mgs. per 950 cc. of solution; the solutions (950 cc. in the sample) were evaporated just to dryness on a water bath under vacuum and an accurate recovery was obtained. Most of the determinations

were made on samples composed of whole plants of wheat, barley, or peas, plus the residual nutrient solutions in which they grew. If this modified method be in error all attempts to locate that error have failed and any suggestions or criticisms are welcome.

Attention to detail is essential to accurate determinations; for this reason it is well to mention a few details of manipulation that have been found of value:

1. It is the habit of some analysts to wash down the neck of the Kjeldahl flask during the process of digestion; in the interests of personal safety and certainty of results this should be avoided. Such a practice introduces water into the sample and operates against the advantages of a previous evaporation under vacuum. If sulphur collects in the neck of the flask it can be removed easily by heating gently and uniformly the neck of the flask in the open flame; by using a strong hot flame during the last hour of digestion the accumulation of sulphur is almost entirely avoided.

2. If excess solid organic matter is present in the sample it may be necessary to increase the amount of salicylic acid mixture used in order to maintain a liquid condition of the contents during the first part of digestion.

3. The open flame should be allowed to come in contact with only that portion of the flask which is covered by the solution. Use an asbestos ring to prevent this (Paul and Berry, '21).

4. In the presence of organic matter, the tendency of the digesting mixture to foam and spew out presents an irritating problem. This loss by foaming has been entirely overcome in this laboratory by allowing the acid to thoroughly disintegrate the solid portions of organic matter, without heat, over an approximate 12-hour period It is advisable to redistribute the acid by occasional shaking. It is necessary to stopper the flasks tightly with rubber corks to prevent the absorption of ammonia fumes. The practice used by the author has been to add the acid and allow the mixture to stand over night. Of the 380 determinations mentioned above, not one has been lost due to foaming when this method was followed.

5. For evaporation of the samples a 5-hole, constant-level, gas-heated water bath is used; the flasks are held on this bath in an

inclined position by 2 notched wooden supports and connected to an ordinary water filter-pump by a series of 5 corks (rubber) and 4 Y-tubes. A 3-liter safety bottle is placed between the filter-pump and the flasks on the water bath to prevent the entrance of water into the flasks when, for any reason, the water pressure becomes reduced. In operation, a partial vacuum is quickly developed and ebullition proceeds at a rapid rate, providing all rubber connections are sufficiently thick-walled to withstand the vacuum developed. Evaporate the sample just to dryness, not to an ash-dry condition. Release the vacuum slowly before removing the flasks; if released rapidly the flasks will crack.

6. A few Pyrex glass beads or small angular pieces of broken Pyrex glass placed in the flask will facilitate evaporation and subsequent digestion; they may be used over and over again.

7. "Bumping" during distillation is a question of concentration and relative abundance of insoluble substances present—at a dilution of 400 cc. practically no "bumping" was experienced.

8. To determine the correct amount of alkali to use in distillation the following test is of value: When ready to distill, add 2 drops of phenolphthalein indicator; add the paraffin, sodium hydroxide, and zinc; after the flask is connected to the distillation apparatus and the flame is adjusted, shake the flask vigorously and if the correct amount of alkali has been added the pink color of the indicator will flash through the solution for 1 to 2 seconds and disappear. If the pink color lasts for more than 2 seconds it is advisable to add more alkali; if the color disappears in less than 1 second a useless excess of alkali is present. Once adjusted the amount of alkali remains practically constant as long as the amount of acid used in digestion is not varied.

In the first part of this paper reference was made to certain criticisms against various methods which are based on the reduction of nitrates in acid medium, and it was also shown that those criticisms against the official method (Assoc. Off. Agr. Chemists, '21) were satisfactorily confirmed in this laboratory. These same criticisms are not applicable, however, to the modified method here reported. A critical study of the data upon which these criticisms are based reveals the fact that the moisture content of the samples was not adequately controlled.

It is pertinent to this investigation, therefore, although no attempt has been made to go into the literature, that all such criticisms which did come to notice[1] be considered. In doing so it is to be remembered: (1) that the accuracy of the modified official method here proposed has been tested out for plants and nutrient solutions only, (2) that, while no difficulty is anticipated in using this method on other biological substances in watery medium (for example, soil extracts), no broad generalizations are advanced until these tests are actually made, (3) that a criticism of the principle upon which this method is based, that is, the acid reduction of nitrates, is also an indirect criticism of the method here used, though the particular method under criticism may be that of Jodlbauer (Metge, '18, p. 30), Förster (Krische, '06, p. 71), etc.

After the completion of this investigation a reference to the work of Allen ('15) became available. Allen's work was very carefully done and is referred to often. In his summary, referring to reduction methods, he concludes that "of such procedures only the modified Devarda and aluminium reduction methods gave promise of meeting our requirements." The data presented indicate that these methods (that is, 2 Devarda methods and 1 aluminium reduction method) were the only ones actually tested out by Allen ('15). He rejected the acid methods of nitrate reduction, apparently upon the evidence presented by Mitscherlich and Herz ('09), as follows:

"Mitscherlich and Herz conducted an extended investigation on the perfection of an accurate Kjeldahl method which would include all forms of nitrogen, in course of which they studied, among other sources of error, the question of the reduction of nitric nitrogen. Using phenolsulfonic acid and zinc dust, sodium hydroxide, and zinc-iron dust, Jodlbauer's method, and Förster's method, they were unable to obtain the theoretical amount of ammonia from nitrate." (Allen, '15, p. 522).

Reference was then made to the work of Mitscherlich and Herz ('09), whose data is an excellent tribute to accurate procedure.

[1] After this paper had been sent to the publishers a reference to the work of W. E. Loomis (Am. Soc. Hort. Sci. Proc. **1924**: 365–370) was found. From the data of 7 reported determinations the official salicylic-thiosulphate method is discarded by Loomis. The criticisms advanced against this method and against the principle of the acid reduction of nitrate are essentially the same as the criticisms previously advanced by Gallagher ('23), which will be considered later in this paper.

For the purposes of this study, however, attention must be called to certain facts pertaining to their report ('09):

1. Of the 40 pages devoted to the report, only 12 (pages 307–318) are concerned with a study of any method based on the reduction of nitrates in acid medium.

2. Through their data they give no detailed statement of procedure for any of the many methods they used, except for that modification of the Devarda method which they recommend (Mitscherlich and Herz, '09, p. 280). They refer to the other methods by name only (for example, Förster, Jodlbauer, etc.), and it is logical to assume, therefore, that the procedures for the methods used were those in common use at the time. For example, the Förster method in use at that time was in part as follows:

"0.5 g Salpeter (50 ccm der Lösung 10:1000) werden in einem Kjeldahlkolben mit 15 ccm einer 6%igen Phenolschwefelsäure oder mit 15 ccm einer 6%igen Salizylsäure-Schwefelsäure vermischt, . . ." etc. (Kirsche, '06, pp. 71–72).

The procedure for the Jodlbauer method is very similar:

". . . : 250 ccm Wasser werden mit 25 ccm Phenolschwefelsäure im Kjeldahl-Kolben versetzt und nach Zugabe einiger Sandkörnchen möglichst weit eingedampft. . . ." etc. (Metge, '18, p. 20, no. 13).

Attention is called to the presence of water in the samples determined by these methods.

3. Finally, attention must be called to the fact that the determinations upon which Mitscherlich and Herz ('09) based their conclusions and to which Allen ('15) referred were made upon samples in water solutions or upon soil extracts, some of which were very dilute. Most of the tables presented have headings similar to the following examples:

"Analyse einer Kaliumnitratlösung mittels der Zink-Eisenstaub-Reduktionsmethode" [table 37, p. 316].

"Versuche zur quantitativen Reduktion des Salpeterstickstoffs einer Kaliumnitrat-Lösung" [table 38, p. 317].

"Stickstoffbestimmung in einem Bodenextrakt nach der Zinkeisenstaub-Reduktionsmethode" [table 36, p. 315].

In explanation of the data in table 34, p. 313, the following occurs:

"Nach der Reduktion der auf je 1 L verdünnten Mengen der Kaliumsalpeterlösung durch zwei Stunden langes Erhitzen auf fast 100° unter Zusatz von 5 g Zinkstaub und 5 ccm Phenolschwefelsäure, nach darauffolgendem Eindampfen und Destillieren wurden folgende

Ammoniakmengen entsprechend ccm N/50 H_2SO_4 im Destillat festgestellt:" [table 34, page 313].

In a few cases the solutions apparently were evaporated and theoretical recovery of nitrogen was not obtained (Mitscherlich and Herz, '09, p. 316). In most of these cases some acid was added (table 32, p. 312; table 35, p. 314) prior to evaporation and in the other cases no statement can be made due to the absence of specific details of procedures.

From a study on the determination of nitrites and nitrates in plants Strowd ('20) concluded that "the determination of nitrates in plants by finding the difference between the Kjeldahl-Gunning-Arnold method and the Kjeldahl method modified to include nitrates is unsatisfactory." Strowd attempts to explain this discrepancy on the basis that "appreciable amounts of nitrate were apparently reduced without zinc and salicylic acid." These deductions were based on 2 determinations only (Strowd, '20, table 1); one being a determination of the nitrate-nitrogen content of a "Pure $NaNO_3$ solution," and the other a "Pure $NaNO_3$ solution + nitrate-free plant extract." By calling attention to these facts it is not implied that the difference between the nitrogen obtained by the Kjeldahl-Gunning-Arnold method and the modified official method, as here reported, would be accurate for the determination of nitrate-nitrogen only—this is another problem. The purposes of this investigation are served by calling attention to the presence of water in the samples determined (Strowd, '20).

For the determination of total nitrogen in plants Gallagher ('23, p. 67) concludes that "nitrate reductions are invariably essential in dealing with Kjeldahl estimations of plant products, since the plant contains nitrates at nearly all stages of growth." He recommends a Devarda method to accomplish this and discards the principle of acid reduction of nitrates on a purely theoretical basis as follows:

"In the estimation of nitrates by means of acid reducing agent a serious objection exists when amino groups, whether in the form of amino acids, or of proteins, etc., be present. The first step in the reduction of nitrates would appear to be the formation of nitrites. In the presence of acid, nitrous acid is formed, which, of course, will quickly react with the amino groups of amino acids, etc., with liberation of nitrogen."

Under certain conditions, and for the method (Ulsch) involved this may be a true statement of fact, but it is not true as a generalized criticism of the reduction of nitrates in acid medium. In acid medium, for example, concentrated sulphuric acid, in the absence of water, and in the presence of either phenol or salicylic acid, the above generalization probably does not hold true. Skeleton equations to illustrate the transformation of the nitric-acid radicle into ammonia may be somewhat as follows, in the case of phenol:

(1) $C_6H_5.OH + HNO_3 = C_6H_4.OH.NO_2 + H_2O$

(2) $C_6H_4.OH.NO_2 + 3H_2 = C_6H_4.OH.NH_2 + 2H_2O$

(3) $C_6H_4.OH.NH_2 + NaOH = C_6H_4.OH.ONa + NH_3$

A very similar transformation takes place with salicylic acid; the reduction process is hastened by the addition of zinc or sodium thiosulphate. By equation (1) it is evident that nitric acid is responsible for the nitrification of the phenol- or salicylic-acid molecule. The nitric acid is obtained from the action of the sulphuric acid on the nitrate present:

(4) $NaNO_3 + H_2SO_4 = NaHSO_4 + HNO_3$

If water is present in the sample to be determined it is probable that the nitric acid will be diluted below the point at which it can quantitatively nitrify the phenol or salicylic-acid molecule; if so, the instability of the nitric-acid molecule will be manifest and there will be a loss of nitrogen-dioxide gas:

(5) $4HNO_3 = 2H_2O + 4NO_2 + O_2$

In fact, in many cases when even small amounts of water are present, visible amounts of nitrogen-dioxide fumes may be given off. The above generalization by Gallagher ('23, p. 64) is based on the reported data of 2 determinations only; the first one being the analysis of ". . . . a *solution*[1] containing nitrate only, . . . ," and the second being the analysis of ". . . a *solution* containing 14.84 mg. of nitrate nitrogen and 9.13 mg. of nitrogen in the form of asparagine. . . ." He obtained a nitrogen loss of approximately 20 per cent.

[1] Italics ours.

Summary

For the determination of total nitrogen in plants and plant solutions the official salicylic-thiosulphate method has proved inadequate. The inaccuracies of this method are demonstrated to be due, primarily, to the presence of water in the sample under analysis. A modification of the official salicylic-thiosulphate method is proposed and certain details of manipulation are discussed. Under the conditions of this investigation this proposed modified method has proved to be approximately twice as rapid and just as accurate as a modified Devarda method used for comparison purposes. Some of the criticisms advanced against the principle of acid reduction of nitrates are reviewed.

It is with pleasure that the author acknowledges his indebtedness to Dr. B. M. Duggar, whose kindly interest, many suggestions, and keen criticisms have been a constant source of strength in this investigation. Acknowledgements also are made to Dr. George T. Moore for the use of the facilities of the Missouri Botanical Garden, and to Dr. E. S. West, Dr. Paul S. Rider, and Dr. Roland La Garde for the timely suggestions and assistance they have gladly given.

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Explanation of Plate

PLATE 19

Apparatus used for the evaporation of the samples under vacuum.

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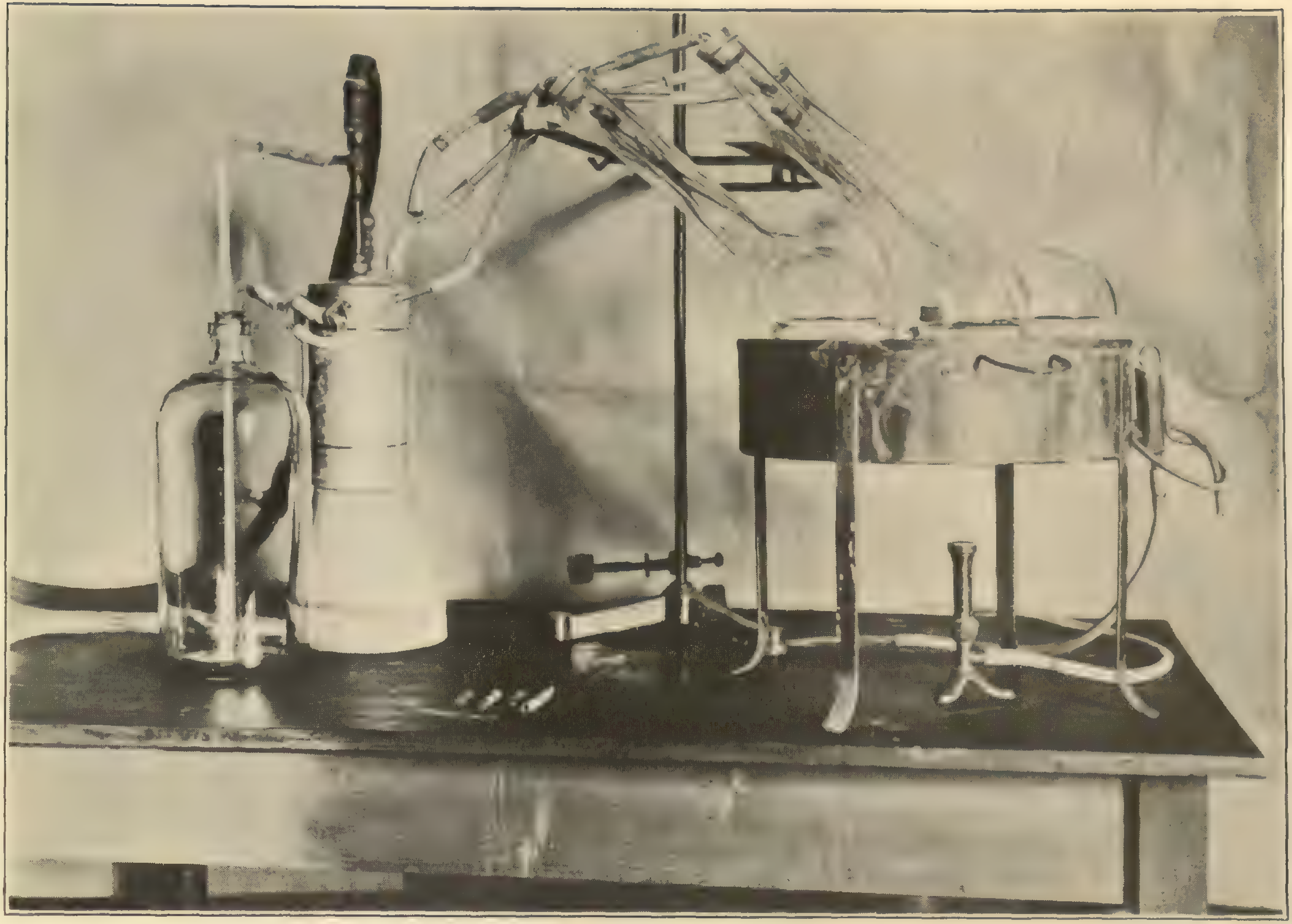

RANKER—DETERMINATION OF TOTAL NITROGEN

COLLOIDAL SULPHUR: PREPARATION AND TOXICITY

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There is urgent need for a fungicide which may be used effectively, without danger of injury, on a variety of plants under diverse conditions.

Sulphur has long been known to have fungicidal properties. Previous to 1880 it was almost the only fungicide in use, doubtless due, in large part, to its abundance and low cost. In the years 1848, 1852, and 1853, during the serious outbreaks of the grapevine mildew in France (Bourcart, '13) it played an important part as a fungicide. The diversity of the forms and compounds of sulphur has had an important bearing upon the use of this substance as a fungicide. The application of a mixture of lime and sulphur for the control of grape mildew was recorded as early as 1833 (Scott, '08), before the use of fungicides became general. Lime sulphur is at present the form of sulphur most widely employed and it ranks high among the standard spray mixtures. However, the use of this spray has been limited to a certain extent because of the caustic effect upon the foliage of certain plants, due to the soluble sulphide content. Serious burning is often reported from its use on apples, which are among those plants least susceptible to this type of injury. The application of this preparation to stone fruits is usually considered unsafe, and it cannot be satisfactorily used on the small fruits and many other plants.

A number of theories have been proposed respecting the toxic constituent of the different forms of sulphur, and until recently the problem was a subject of considerable speculation. A complete review of the earlier investigations has been given in a recent paper by Young ('22). This investigator demonstrated that regardless of the form of sulphur employed as a fungicide, whether as a compound or as uncombined sulphur, the lasting toxicity is due to an oxidation product of the sulphur itself. He further proved that the toxic substance is liberated most

[1] A fellowship established by the Crop Protection Institute for the investigation of sulphur as a fungicide.

rapidly from sulphur in a very finely divided state, that is, from colloidal sulphur.

Experimental

Since the experimental evidence gained from laboratory tests, up to the present time, has shown that colloidal sulphur has greater fungicidal value than other forms of sulphur, it was thought important to study the methods of its preparation. The primary object was to perfect a method or methods which would serve as a basis for commercial production of colloidal sulphur. After studying a variety of preparations, those materials which indicated sufficient promise were thoroughly tested for injury on the foliage of a variety of plants growing in the greenhouse. The plants used in these tests were the following: peach, potato, tomato, squash, cucumber, cantaloupe, geranium, tobacco, sweet-potato, and rose. Several of these plants were found to be very susceptible to injury by certain sulphur compounds. In those cases in which injury resulted a further study was made in an effort to eliminate the injurious property. The toxicity of the materials was then tested, using the percentage of germination of spores of a variety of economic fungi as indicators. The Van Tieghem cell or the modified hanging-drop culture method used by Young ('22) was employed in this work. The following organisms were used: *Botrytis Alii*, *B. cinerea*, *Colletotrichum Gossypii*, *Glomerella cingulata*, *Gloeosporium venetum*, *Macrosporium sarcinaeforme*, *Sclerotinia cinerea*, and *Ustilago Hordei*. The spores were taken from cultures 10–15 days old, grown on dextrose-potato agar prepared by the method of Duggar, Severy, and Schmitz ('17), except in the case of *Ustilago Hordei*. The spores of the latter organism were obtained from smutted barley heads, freshly collected in the field.

The culture solution used in the hanging drops and in which the sulphur materials were suspended, except in cases otherwise indicated, was a slightly buffered mixture prepared according to the method of Karrer and Webb ('20) and of Young ('22), as follows: Stock solutions of M/5 mannite in M/10 phosphoric acid and of M/5 mannite in M/5 sodium hydroxide were prepared. Equal quantities of the M/5 mannite-M/10 phosphoric acid were

placed in each of ten flasks and successively increasing proportions of M/5 mannite-M/5 sodium hydroxide were added. The flasks were plugged with cotton, sterilized at 15 pounds pressure for 15 minutes, and allowed to stand for a few hours. Titrations made by the colorimetric method (Clark,'20) showed the mixture to have the following range of hydrogen-ion concentrations: P_H 2.4, 3.4, 4.2, 5.0, 5.4, 5.8, 6.2, 6.8, 7.4, 8.4.

THE PREPARATION OF COLLOIDAL SULPHUR FROM SODIUM THIOSULPHATE AND SULPHURIC ACID

It has been shown by Young ('22)[1] and others that when a saturated solution of sodium thiosulphate (hypo) is mixed with concentrated H_2SO_4, a colloidal sulphur is formed having extremely small particles. In order to free the sulphur from the acid solution, it was coagulated with concentrated NaCl and centrifuged out of suspension. The coagulum was then peptized with water. By repeating the coagulation, centrifuging, and peptizing, a pure sample of colloidal sulphur is obtained—except for traces of the salt. This form of colloidal sulphur was found to have a high fungicidal value, but the method of preparation proved to be impractical for its production on a commercial basis.

There remained one other possible method of remedying the acid-hypo mixture, so that it might be used as a spray; namely, to neutralize it with an alkali. Young ('25) also encountered difficulties in this process. He first used NaOH to neutralize his hypo-acid mixture and found this alkali to be unsatisfactory because the concentration of the electrolyte soon precipitated the soluble sulphur. He later used lime sulphur to neutralize the mixture and prepared the material as follows: Fifteen gallons of saturated hypo were slowly stirred into 5 gallons of concentrated H_2SO_4 in a wooden barrel. The mixture was filtered through a fine screen and the filtrate neutralized with lime sulphur diluted one to three with water. During the addition of the lime sulphur, which was slowly effected, a further quantity of 3 gallons of concentrated hypo was introduced. Analysis of the final mixture

[1] Young gives a review of the earlier investigations upon this method of preparing colloidal sulphur.

showed that 1 gallon contained 10 ounces of soluble sulphur. He suggested that if the mixture could have been centrifuged at this point it would have made an excellent spray. As a result of the conditions, however, the soluble sulphur soon precipitated.

When the hypo and H_2SO_4 are mixed according to the method just described, there is a large quantity of insoluble sulphur formed which is thrown out in the form of a gummy mass. This insoluble mass must be filtered off, as has already been indicated, before further procedures. It appeared logical to suspect that this waste could be prevented to a large extent by the introduction of certain glutinous colloids which might be assumed to act as protective colloids. Likewise, the introduction of such colloids might be assumed to exhibit further protective action by preventing the precipitation of the soluble sulphur when electrolytes are added to neutralize the mixture.

E. von Meyer and Lattermoser (Taylor, '21), in 1897, were the first investigators to recognize that the addition of a very stable sol to a less stable sol, that is, an emulsoid to a suspensoid, prevented the precipitation of the latter by salts. The latter author reached the conclusion that the addition of very stable colloids, such as albumin, gelatin, agar, or gum arabic, to a silver sol, prevented precipitation by electrolytes until the stable colloid is gelatinized. In 1902, Zsigmondy ('09) investigated this "protective" action of colloids quantitatively by means of his gold sol, which in pure aqueous solution is itself very stable, but is also very sensitive to salts. The degrees of protection of various substances, such as gelatin, casein, egg-albumin, dextrin, starches, cane sugar, etc., were expressed by the "gold number." Further discussion in this paper will be limited to the use of protective colloids in the preparation and utilization of spray materials.

Various organic and inorganic substances have been recommended by different investigators for increasing the spreading and adhesive qualities of fungicides and insecticides. Though many of the early investigations dealt primarily with the spreading and adhesive qualities of sprays, it is reasonable to assume that the physical qualities were also improved in many cases.

Glue was one of the first substances used as a spreader. Mil-

lardet and Davis (Moore, '21) in 1885 used glue with Bordeaux mixture in the treatment of mildew of the vine, thinking that glue increased the efficiency of the mixture. Lowe ('96) found that glue added to lead arsenate, in the proportion of 2 quarts to 45 gallons of spray, gave satisfactory results in spreading the spray evenly over the foliage of cottonwood. Surface ('05) used glue to increase the adherence of lime-sulphur spray.

More recently Jones ('19) has obtained a patent covering the use of glue as a stabilizer for oil emulsions so that they will mix with lime-sulphur solutions. Yothers and Winston ('24) state that such substances as casein, skimmed milk powder, gelatin, corn meal, wheat flour, and starches are as effective as glue in rendering oil emulsions miscible with lime-sulphur solutions.

Various kinds of soaps have been very commonly employed as spreaders. Gillette ('90) was one of the first investigators to report the use of soap as a spreader for insecticides, namely, Paris green and London purple. Washburn ('91), Galloway ('92), and Swingle ('94) are other early investigators to recommend the use of soaps.

A little later those interested in the field began to investigate the use of spreaders quantitatively. Van Slyke and Urner ('04) showed by chemical analysis that different kinds of soaps varied greatly in water content. Therefore, it was concluded that the addition of a definite quantity of soap to sprays may or may not increase their spreading qualities.

Vermorel and Dantony ('10) studied the surface tension of soap solutions in relation to their ability to spread over a surface. They state that whether or not the addition of soap to fungicides will increase their spreading qualities depends upon the method used in the preparation of the mixture. Parker ('11) recommended the addition of soap to certain arsenical sprays to retard settling and likewise increase spreading qualities.

Lovett ('18, '20) made a rather extensive study of the use of spreaders with arsenical sprays. He concluded that the ability of a solution to hold arsenate in suspension, while not necessarily a criterion as to its value as a spreader, does indicate a physical quality in the solution much to be desired in a spreader. Various organic substances were tested, such as caseinate, glue, gelatin,

sage tea, soap bark, and starches. He arranged the materials tested in the order of their merit, based on compatibility, efficiency, availability, cost, and ease of preparation, as follows: caseinate, glue, gelatin, and soap bark. A number of inorganic compounds were also tested. Oil emulsion gave very promising results, while other inorganic materials were unsatisfactory.

Moore ('21)[1], in a quantitative study of the spreading and adherence of arsenical sprays, found that the addition of materials similar in chemical constitution to the leaf surface causes the spray mixture to form a continuous film over the foliage. Various protein substances and plant infusions gave effective spreading on leaves with surfaces of cellulose, even when they are strongly cutinized. The suspensions containing small-sized particles were found to adhere better than those of larger-sized particles.

Recently, Brinley ('23) has recommended a method of preparing colloidal lead arsenate. The method consists in precipitating the lead arsenate in the presence of a protective colloid, such as gelatin, by the chemical reaction between lead nitrate and disodium arsenate. He found that the method of mixing and diluting the chemicals was a very important factor in obtaining a solution of greatest stability.

Since most of the evidence in the foregoing references points to organic substances as being more effective than inorganic substances in preserving the stability of solutions, it was thought desirable to test the hypo-H_2SO_4 mixture as prepared with certain glutinous colloids. Thus dextrin, peptone, starch, gelatin, and glue were tested in varying percentages. Dextrin and peptone did not prove of any value in preserving the stability of the solution. While starch possesses certain desirable characteristics, gelatin and glue proved to be more satisfactory. The results obtained with gelatin were slightly less desirable than those obtained with glue. Therefore, considering the materials upon their merits, as to efficiency, cost, and availability, glue should be recommended in preference to gelatin.

The hypo and H_2SO_4 were diluted in a number of ways before mixing and the stability of the resulting solutions was tested as prepared with glue. Likewise the stability of the solution was

[1] A review of the history of spreading is given.

tested as prepared with different proportions of the chemicals. Smaller quantities of the hypo in proportion to the H_2SO_4 gave best results. The most satisfactory results were obtained by introducing the glue immediately after the chemicals were mixed. If the mixture is allowed to stand any length of time before the glue is added, the stability of the solution is lost; and, further, the introduction of glue to either chemical before mixing results in the loss of a considerable quantity of sulphur, the latter being thrown out of solution in an insoluble mass.

Since temperature has been shown to be an important factor in the preparation of other colloidal solutions, as well as sulphur, the effect of employing warm solutions was tested, with thoroughly satisfactory results. Wackenroder ('46) observed that low temperatures caused a large part of the sulphur particles to settle out of solution.

In order to neutralize the hypo-H_2SO_4 mixture, while at the same time preserving the stability of the solution and likewise the toxic property of the colloidal sulphur, it was necessary to employ various alkalies. After preliminary tests, strong alkalies were eliminated as unsatisfactory. Sodium carbonate and some other weak alkalies proved satisfactory. Raffo ('08) used Na_2CO_3 to neutralize a sulphur suspension, made from hypo and H_2SO_4, after the sulphur had been centrifuged out of suspension and again peptized with water. The greater part of the sulphur was precipitated, leaving a stable solution of sulphur containing a little Na_2SO_4. The use of glue prevented, to a large extent, the precipitation when weak alkalies were added.

After testing various methods as indicated in the foregoing discussion, the method which proved most satisfactory was as follows: Fifty gms. of hypo were dissolved in 40 cc. of water and warmed to 40–50° C.; 40 cc. of H_2SO_4, specific gravity 1.84, were measured into a 500-cc. glass cylinder. The warm saturated solution of hypo was added slowly to the H_2SO_4 with occasional stirring. Eighty cc. of warm water (30–40° C.) were immediately added to the mixture, followed by the same quantity of 1 per cent glue solution of the same temperature. The temperature, as indicated in each case, is a very important factor and one on which, to a large extent, the stability of the solution depends.

The mixture was allowed to stand 48 hours, after which time the reaction was adjusted to P_H 4.2 with a saturated solution of Na_2CO_3 and then aerated for 30 minutes. The aeration is necessary to free the solution of traces of SO_2 which is very injurious to the foliage of plants. The addition of water as indicated is a very important step in the process. It changes the physical state of the solution to such an extent that the solution will remain stable for several days without the addition of a protective colloid. In this connection, Sobrero and Selmi (Taylor, '21), in 1850, investigating colloidal sulphur formed by the reactions of SO_2 and H_2S in water, make the following remark: "If water is added to it [colloidal sulphur] it divides up, forming an emulsion from which it does not separate out, even on prolonged standing [several months]."

A saturated solution of dibasic sodium phosphate may be used for neutralizing the mixture. It may be added to the hypo-acid mixture immediately, thereby eliminating the necessity of allowing the mixture to stand 48 hours before adjusting the reaction.

After the two solutions were thoroughly tested on the foliage of plants, toxicity tests were made. The method employed in preparing the sulphur suspensions for testing was essentially the same as that used by Young ('22) in his toxicity studies, and was as follows: Three test-tubes were provided with pipettes that extended through the cork stoppers to the bottom of the tubes. By this means drops could be transferred readily to the hanging-drop cells. Ten cubic-centimeters of the slightly buffered solution, P_H 4.2, were added to each tube. This gave a duplicate series, one tube each for the two sulphur suspensions to be tested and one for the control culture. One cubic centimeter of the sulphur suspensions was added to the tubes.

The technique of planting the hanging-drop cultures was the same as that employed by Webb ('21) in his germination studies and later slightly modified by Young ('22), and was as follows: Ground-glass rings were cemented to glass slides by means of parawax and petrolatum. Two of these rings were placed on each slide and 3 slides constituted a series for each organism. A large drop of the sulphur suspension to be tested for toxicity

was placed in the bottom of the two cells. Another drop was placed on each slide and three slides constituted a series for each organism. A large drop of the sulphur suspension to be tested for toxicity was placed in the bottom of the two cells. Another drop was placed on a clean sterile glass slide. A definite spore suspension was made in the drop. By means of a small sterile glass rod a small part of the drop was transferred to a clean sterile cover-glass and spread out in the form of a smear. The cover-glass was inverted and sealed air-tight by means of petrolatum over the glass cell. The cultures were incubated at 23° C. and germination counts made at the end of 18 hours. The results are recorded in table I.

TABLE I

TOXICITY OF CERTAIN FORMS OF COLLOIDAL SULPHUR. THE FIGURES INDICATE PERCENTAGE OF GERMINATION[1]

Form of sulphur	Organism				
	Botrytis cinerea	Colletotrichum Gossypii	Glomerella cingulata	Macrosporium sarcinaeforme	Sclerotinia cinerea
Control—without sulphur	80	65	76	94	60
Colloidal sulphur neutralized with Na_2CO_3	5	0	8	44	2
Colloidal sulphur neutralized with Na_2HPO_4	15	4	12	57	5

[1] Average of duplicate tests run at two different times.

The results in this table show that both colloidal sulphur solutions tested were toxic to all the organisms used. The solution prepared with disodium phosphate was slightly less toxic than that prepared with Na_2CO_3. This can be accounted for in that it required more of the phosphate to neutralize the mixture. Therefore, there was less sulphur in the mixture.

THE PREPARATION OF COLLOIDAL SULPHUR FROM LIME SULPHUR

Since the introduction of lime sulphur as an orchard spray serious injuries to foliage of plants have been frequently reported as a result of its use. Injury is often more frequent when the spray is used in combination with certain arsenicals. This is shown by a survey of the literature from various agricultural experiment stations. A number of methods for the elimination of these difficulties have been suggested by different investigators, all of which relate primarily to the method of diluting, mixing, and applying the spray, or to the time of application, or the evidence of inferior compounds. Since lime sulphur is composed largely of sulphides (pentasulphides) the caustic action on foliage of plants has been attributed to these soluble compounds. A few investigators have suggested that the injurious properties can be eliminated by precipitating the soluble sulphides with salts or acids. These methods, however, have not come into general use.

Wallace ('10), in a study of lime-sulphur spray injury, precipitated commercial lime sulphur, diluted 1–30 with water, by applying it with a carbonic-acid gas sprayer. The solution was allowed to stand in contact with the gas one-half hour before the application of the spray. A heavy white precipitate was formed, and this did not cause injury to apple and peach foliage when used alone as a spray. However, when lead arsenate was introduced into the mixture before the precipitation, the resulting material used on young peach trees caused almost complete defoliation.

Stewart ('12), in a similar study, pointed out that lime-sulphur-arsenical injury could be eliminated by precipitating the mixture with iron sulphate, or "copperas," added at the rate of 3½ pounds to 50 gallons of 1.01 spray solution. The mixture was found to be very disagreeable to handle, due to its tenacious and blackening qualities. Also serious discoloration of fruit resulted from its use, and the effectiveness of arsenicals was reduced. Waite ('10) had previously reported the use of iron sulphate and copper sulphate in the preparation of self-boiled lime sulphur.

Safro ('13), after a study of lime sulphur spray injury, con-

cluded that the effect was due to the soluble sulphide content of the spray. He found that the injury could be reduced by rendering the sulphides insoluble, that is, by precipitating them. His results indicated that the injury could be reduced by the addition of either iron, copper, or zinc sulphate, the salt being first dissolved in water, in the proportion of 4 pounds to 100 gallons of diluted (1 to 20) lime-sulphur solution. Carbon dioxide and H_2SO_4 were also used, the substances being introduced until the remaining sulphides gave the spray an amber color. The carbon dioxide entirely eliminated the injury.

More recently, definite methods have been given for precipitating lime sulphur for commercial use. Ramsay and Cooke ('22) describe a method of preparing colloidal sulphur from lime sulphur which has been used effectively as a spray in Australia. The method recommended is as follows: Ten gallons of home-made lime sulphur, 26° Baumé, were diluted with 25 gallons of water in a barrel of 40 or 50 gallons capacity. Using a porcelain or earthenware vessel, 6 pints of strong commercial H_2SO_4 were poured slowly into 9 pints of cold water and the solution allowed to cool. The cold diluted H_2SO_4 was then added to the diluted lime sulphur, 2 or 3 ounces at a time, stirring well after each addition of acid, until the typical yellow color of the original lime-sulphur disappeared and until the addition of H_2SO_4 produced no further precipitation of sulphur. The precipitated sulphur was allowed to settle for a day or two and the clear liquid above was siphoned or decanted off. Three pounds of cheap glue were dissolved in just sufficient hot water to render the glue soluble, and, while still hot, stirred thoroughly into the precipitated sulphur. For use, the mixture thus obtained was diluted with water to 250 gallons. This gave approximately 5 pounds precipitated sulphur per 100 gallons of spray.

After making a study of the toxicity of the various ingredients of decomposed lime sulphur, Young ('22) showed conclusively that the lasting toxicity was due to the precipitated sulphur. This form of precipitated sulphur was found to be about as toxic to parasitic fungi as "hydrophobic" colloidal sulphur. Later ('25) he prepared colloidal sulphur from lime sulphur as a summer spray. The results from the use of this material in

combating apple scab were very encouraging. His method was as follows: Ten gallons of lime sulphur, 32° Baumé, were placed in a 50-gallon barrel. To this were added 10 gallons of water and 1 pound of glue, the latter previously dissolved in hot water. Sulphuric acid diluted with 3 parts of water was then added until the reaction of the mixture was P_H 4.2. The mixture was allowed to settle and the supernatant liquid decanted off. The mixture contained about 1 pound of active sulphur per gallon. Five gallons of the precipitate were diluted with water to 95 gallons before using as a spray.

Since the recent uses of precipitated lime sulphur as a spray have given encouraging results, it was considered important to make further studies upon its preparation with the object of producing a mixture of greater stability. Likewise from previous tests of toxicity (Young, '22), the mixture would be expected to exhibit greater fungicidal properties. There were several factors which were thought to be important in the preparation, namely: (1) the choice of acids and the dilution of these; (2) the concentration and method of diluting the lime-sulphur solution; (3) the temperature; and (4) the protective colloid, its concentration, and the method of introduction.

The lime sulphur used for this work was a freshly made solution, prepared according to the Van Slyke method, that is, in the proportion of 80 pounds sulphur, 36 pounds lime (CaO), and 50 gallons of water, these ingredients being boiled together one hour. Preliminary tests were made with a number of acids and phosphates to determine which of those were most desirable for precipitating the freshly made lime sulphur. The use of phosphates, of certain acids, and also of strong solutions of acids gave unsatisfactory results and these procedures were eliminated. Weak solutions of HNO_3 and H_2SO_4 gave very promising results. Glue, which proved to be the most satisfactory in the previous preparations, was used as a protective colloid. The concentration of the glue, the method of introducing it, the dilution of the lime sulphur, and the temperature of the solutions employed in the preparation were found to be the important factors upon which, to a large extent, the stability of the solution depended.

Since the preliminary tests showed that the dilution of the

acid used in precipitating lime sulphur had an important bearing upon the stability of the solution, further tests were made in order to determine what strength of HNO_3 and H_2SO_4 could be most satisfactorily employed. Twenty-five cc. of lime-sulphur solution were measured into each of 10 glass beakers of 300 cc. capacity. The beakers were numbered 1–5 inclusive, which gave a duplicate set, one set each for the two acids to be tested. The mixtures were then adjusted to the reaction P_H 4.2, with dilutions of HNO_3 and H_2SO_4 as follows:

No. 1. Acids diluted 1–3 with water.
No. 2. Acids diluted 1–5 with water.
No. 3. Acids diluted 1–10 with water.
No. 4. Acids diluted 1–20 with water.
No. 5. Acids diluted 1–40 with water.

The resulting solutions showed a striking range in stability. The precipitated sulphur in solutions No. 1 settled out of suspension within a few hours after it was prepared. Solutions No. 2 remained stable several days. Solutions No. 3 remained stable about 2 weeks. Solutions No. 4 remained stable several months. Solutions No. 5 were less stable than No. 3. The solutions prepared with HNO_3 possessed slightly greater stability in all cases than those prepared with H_2SO_4. These results show conclusively that the strength of the acid used in precipitating the sulphur is an important factor in producing a product of the desired stability.

After determining the proper dilution of acid to use, further studies were made of different procedures in making the preparation. The method which proved the most satisfactory is as follows: Fifty cc. of freshly made lime sulphur were measured into a glass beaker of 600 cc. capacity. One gram of dry flake glue was dissolved in 200 cc. of water and mixed with the lime sulphur while warm (35–40° C.). Ten cc. of HNO_3 were diluted with water in a separate container. The diluted HNO_3 was then added to the diluted lime-sulphur mixture very slowly, with stirring, until the reaction P_H 4.2 was obtained. The mixture was allowed to set for several hours in the open container, with occasional stirring, to remove the H_2S. This gave a final dilution, in respect to the original lime-sulphur solution, of 1 to 9.

The mixture contained approximately 1.8 per cent sulphur. Colloidal sulphur prepared by this method will remain stable for several months. Sulphuric acid diluted 1–20 may be used to precipitate the lime sulphur mixture. However, as previously indicated, the solution as prepared with H_2SO_4 is less stable.

In determining the toxicity of this form of colloidal sulphur, the mixtures prepared with HNO_3 and H_2SO_4 were compared with lime sulphur precipitated by the CO_2 in the air, the latter being effected as follows: Ten cc. of lime sulphur solution were diluted with 60 cc. of water and this solution was poured into a large open dish and allowed to decompose. The precipitate was then taken up in 70 cc. of water. One cc. of each of these 3 precipitated lime-sulphur solutions was then added to 5 cc. of the slightly buffered mannite-H_3PO_4-NaOH mixture of P_H 4.2 (except in tests with *Macrosporium sarcinaeforme*, where M/5 mannite was used), and the toxicity determined as before. The organisms used and the results are recorded in table II.

TABLE II

TOXICITY OF PRECIPITATED LIME-SULPHUR SOLUTIONS. THE FIGURES INDICATE THE PERCENTAGE OF GERMINATION (AVERAGE OF CULTURES RUN AT 2 DIFFERENT TIMES)

Form of sulphur	Organism				
	Botrytis cinerea	Glomerella cingulata	Macrosporium sarcinaeforme	Sclerotinia cinerea	Ustilago Hordei
Control—without sulphur	84	64	88	59	73
Lime sulphur solution precipitated with HNO_3	24	10	10	0	1
Lime sulphur solution precipitated with H_2SO_4	55	13	30	0	3
Lime sulphur solution precipitated by CO_2 in air	71	—	—	—	21

From the results exhibited in table II it is clear that the toxicity of the sulphur prepared by the different methods is related to

the stability of the sulphur suspensions. The sulphur precipitated from lime sulphur by the CO_2 in the air settles out of suspension in a very short time, and is therefore the least toxic of the three forms of sulphur tested. The solution prepared with HNO_3 possesses the greatest stability and likewise exhibits the greatest toxicity.

The mixtures prepared with HNO_3 and H_2SO_4 were thoroughly tested on the foliage of plants already named growing in the greenhouse. They were found to spread over the surface of the foliage evenly and adhere well; in fact it was difficult to remove the films by washing with a strong stream of water from the hose.

PREPARATION OF COLLOIDAL SULPHUR BY MEANS OF SO_2 AND H_2S

The formation of colloidal sulphur by the reaction between SO_2 and H_2S in water was first recorded by Berthollet (1798). The reaction was later studied by Wackenroder ('46) who discovered pentathionic acid and prepared it by passing H_2S into a saturated solution of SO_2, always keeping an excess of the latter. Lewes ('81), Spring ('82), Shaw ('83), and Débus ('88) are other early contributors to the study of the properties of pentathionic acid formed by this process. The reaction of SO_2 and H_2S has been studied more recently by Riesenfeld and Feld ('21) in a study of polythionic acid and polythionate.

Selmi and Sobrero ('50) (also earlier investigators) made rather extensive studies of colloidal sulphur formed by the reaction of SO_2 and H_2S. A review of the work is given by Odén ('13). That there is more than one state of colloidal sulphur formed by this process is shown by Selmi ('52) who prepared colloidal sulphur as follows: Sulphur dioxide was passed into distilled water until a saturated solution was formed. Hydrogen sulphide was then passed into the saturated solution of SO_2, care being taken not to have an excess of H_2S, as it precipitates the soluble sulphur. The solution was then centrifuged to remove the larger particles and the supernatant liquid coagulated with sodium chloride. The coagulum was then peptized in water. Further evidence of the two forms of colloidal sulphur is given in the papers cited above. Young ('22) has designated the two forms, according to their degree of hydration, as hydrophilic

and hydrophobic colloidal sulphur. There are in all probability several grades of fineness in the hydrophobic forms. This is shown in the work of Odén ('13).

The colloidal sulphur prepared from SO_2 and H_2S in this investigation consists largely of the hydrophobic form. The method used was as follows: A rubber stopper having two holes was provided with two thistle tubes, over the mouths of which finely perforated parchment paper was securely fastened. The tubes were inverted into a 2-liter flask containing 1500 cc. of water, the stopper closing the mouth of the flask. Sulphur dioxide (compressed liquid) and H_2S (made from FeS and 1 to 1 muriatic acid) were passed simultaneously into the water through the thistle tubes, keeping the sulphur dioxide slightly in excess. After three hours a slight excess of H_2S was introduced to free the solution of SO_2. The suspension thus formed contained 12 per cent sulphur, which had great stability. In fact, there was but very little settling out after standing three months.

The efficiency of the method is determined by the fineness of the perforations through which the gases are introduced into the liquid. In the method described the gases are introduced in the form of a fine spray, which permits a more thorough mixing in the solution. The introduction of the gases in the form of large bubbles was found to be inefficient and unsatisfactory in preliminary tests. The use of distilled water has been found more desirable than tap water, especially since the latter may contain sufficient salts or alkalies to effect a partial precipitation of the colloidal sulphur as it is formed.

The colloidal sulphur solution thus prepared has an acid reaction slightly beyond the acid range of available indicators, P_H 1.0. Wackenroder ('46) found that some H_2SO_4 was formed during the process in the presence of oxygen. It was later found difficult to free the mixture entirely of SO_2, and it was evident that traces were left in the solution. The solution was found to be injurious to the foliage of plants; therefore, it was necessary to adjust the reaction, or treat the solution in some way before it could be used as a spray.

The weak alkalies used for adjusting the colloidal sulphur

solution prepared by the hypo-H_2SO_4 method, namely, Na_2CO_3 and the Na_2HPO_4, caused precipitation of the colloidal sulphur when freshly prepared by this method. Similar results were also produced by the introduction of glue or gelatin. However, promising results were obtained by aerating the mixture for 48 hours and then adjusting the reaction to P_H 4.2 with a weak solution of Na_2HPO_4. The resulting solution remained stable for 3 months, after which time the colloidal sulphur was precipitated. This material was found to be very toxic to fungi when first prepared. It proved effective for control of carnation rust in the greenhouse.

Later the colloidal sulphur was coagulated with NaCl and allowed to settle out of solution. The method was as follows: A saturated solution of NaCl was added to the freshly prepared colloidal sulphur suspension until it changed from a bright to a pale yellow color. The mixture was allowed to set two hours, after which time the coagulum had settled out of suspension. The supernatant liquid was then siphoned off and the coagulum washed with water and allowed to settle again. The supernatant liquid was again siphoned off. The sulphur is left in the form of a thin paste, containing about 70 per cent water and a little NaCl. The sulphur readily assumes the colloidal state when further quantities of water are added. Selmi and Sobrero ('50) found that colloidal sulphur prepared from SO_2 and H_2S could be coagulated by a neutral sodium salt, and again be emulsified in water. They state that when potassium salts are used the precipitated sulphur completely loses the property of emulsifying in water.

When the sulphur paste (prepared by the above method) is resuspended in water, shortly after it has been coagulated, the suspension remains stable over a long period of time. In fact, such a suspension was kept in the laboratory for 8 months, and after this there was still little or no settling of the sulphur. However, if the coagulum is not taken up in water, the sulphur begins to crystallize in about 1 month and soon loses its colloidal property. The paste form would be much more desirable for practical use. Therefore further investigations should be made to determine if it can be treated in such way as to prevent crystallization.

The results on the toxicity tests of this form of colloidal sulphur are discussed on subsequent pages.

THE TOXICITY OF CERTAIN FORMS OF COLLOIDAL SULPHUR IN RELATION TO THE HYDROGEN-ION CONCENTRATION

Since it was shown by Young ('22) that the hydrogen-ion concentration has a marked influence upon the toxicity of certain forms of colloidal sulphur, it was thought important to determine if this influence may be exhibited by other forms of these colloidal preparations. A colloidal sulphur solution was prepared from SO_2 and H_2S as already described, with modifications as follows: After the colloidal sulphur had been coagulated with NaCl, the solution was then centrifuged for 15 minutes at 1500 revolutions per minute. The supernatant liquid was then decanted. Upon drying and weighing, the coagulum was found to contain 50 per cent of sulphur.

One gm. of the coagulum was weighed out and taken up in 100 cc. of distilled water. This gave a dilution of sulphur of 0.5 gm. in 100 cc., or 1 to 200. When freshly made, the reaction of the solution was P_H 4.0; after standing in a closed container for 1 week the P_H had changed to 2.2. The freshly made sulphur suspension also changed the hydrogen-ion concentrations of the culture solutions. Therefore it was found necessary to adjust the sulphur suspensions to the range of hydrogen-ion concentrations corresponding to the particular hydrogen-ion concentration of the culture solution, which was done as follows: Fifty-cc. quantities of the 1 to 200 colloidal sulphur suspension of P_H 4.0 were measured into each of 11 clean glass beakers. The suspensions were then adjusted toward and into the alkaline range with an increasing number of drops of M/10 Na_2HPO_4 solution, and into the acid range with M/10 H_3PO_4 solution. This gave a range of hydrogen-ion concentrations as follows: P_H 2.4, 3.4, 4.2, 5.0, 5.4, 5.8, 6.2, 6.8, 7.4, and 8.4. The colloidal sulphur suspension thus prepared did not change the hydrogen-ion concentrations of the culture solution during the 18-hour period of incubation of the cultures. The stability of the sulphur suspensions of different hydrogen-ion concentrations will be discussed later.

In later work it was found that if the coagulation, centrifuging, and peptizing with water is repeated 3 times, the hydrogen-ion concentration of the resulting colloidal sulphur suspension does not change even on prolonged standing. Likewise, such a suspension does not evert the hydrogen-ion concentration of the culture solution. This is probably due to the buffer action of the phosphate which was added.

The culture solution used for making the toxicity studies was the slightly buffered mannite-H_3PO_4-NaOH mixture prepared according to the method already described. Twenty test-tubes were provided with pipettes that extended through the cork

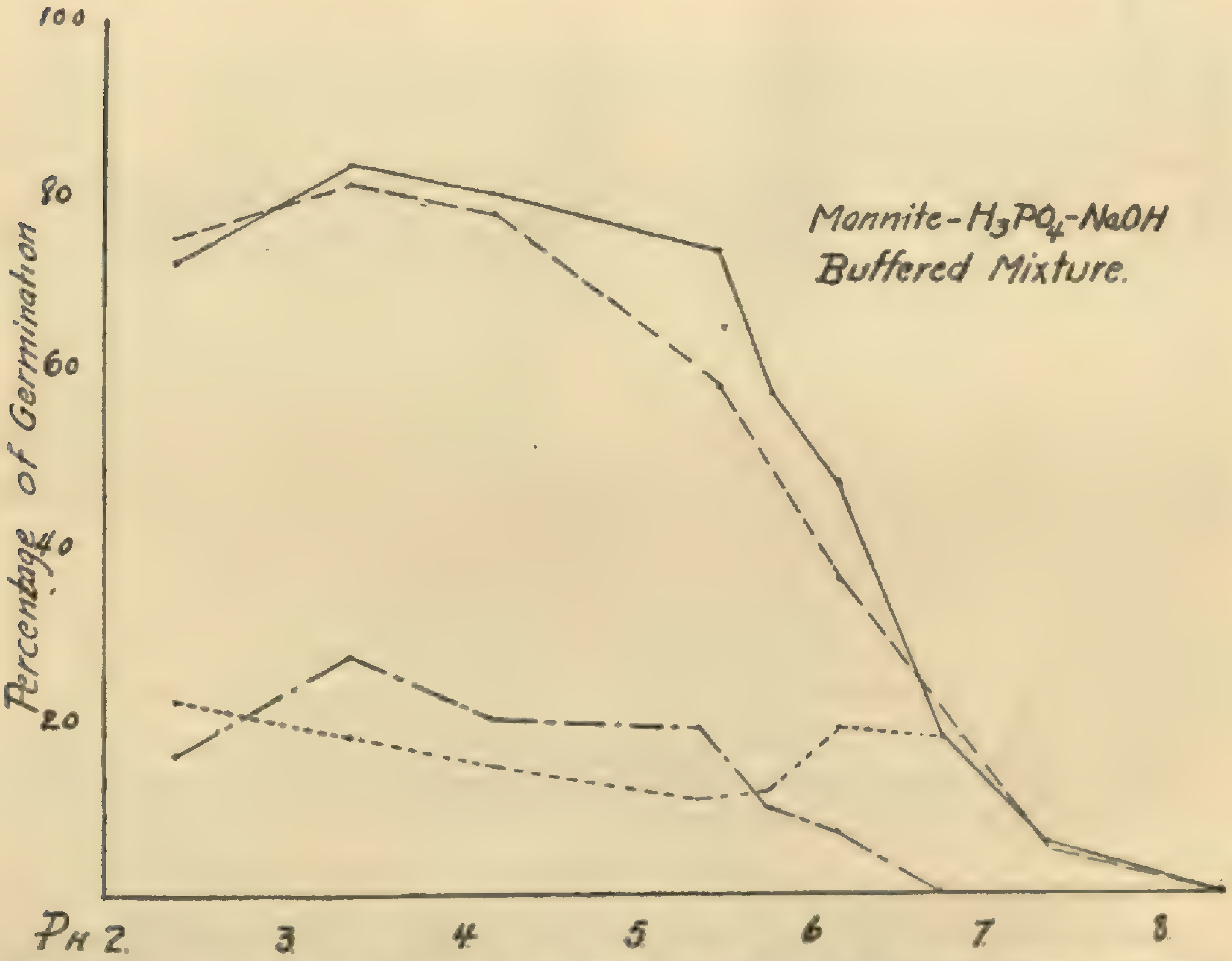

Fig. 1. Germination of spores of *Botrytis cinerea* in hanging-drop cultures: toxic action of certain forms of colloidal sulphur; prepared by method 1— - — -; prepared by method 1, crystallized — — —; prepared by method 2 - - - - -; control, without sulphur————.

stopper to the bottom of the tubes, according to the method employed by Young ('22). This constituted a duplicate series of 10 each, and 10 cc. each of the slightly buffered solutions were added to the tubes so that each tube represented a particular

hydrogen-ion concentration. The colloidal sulphur suspensions were added to one series, with accurately calibrated pipettes, in quantities to make the dilutions indicated in table III.

The hanging-drop cultures were prepared in closed-ring cells according to the method already described, and were incubated at 23° C. After germination of 18 hours, counts were made. The results of these tests are shown in table III, also in figs. 1–4.

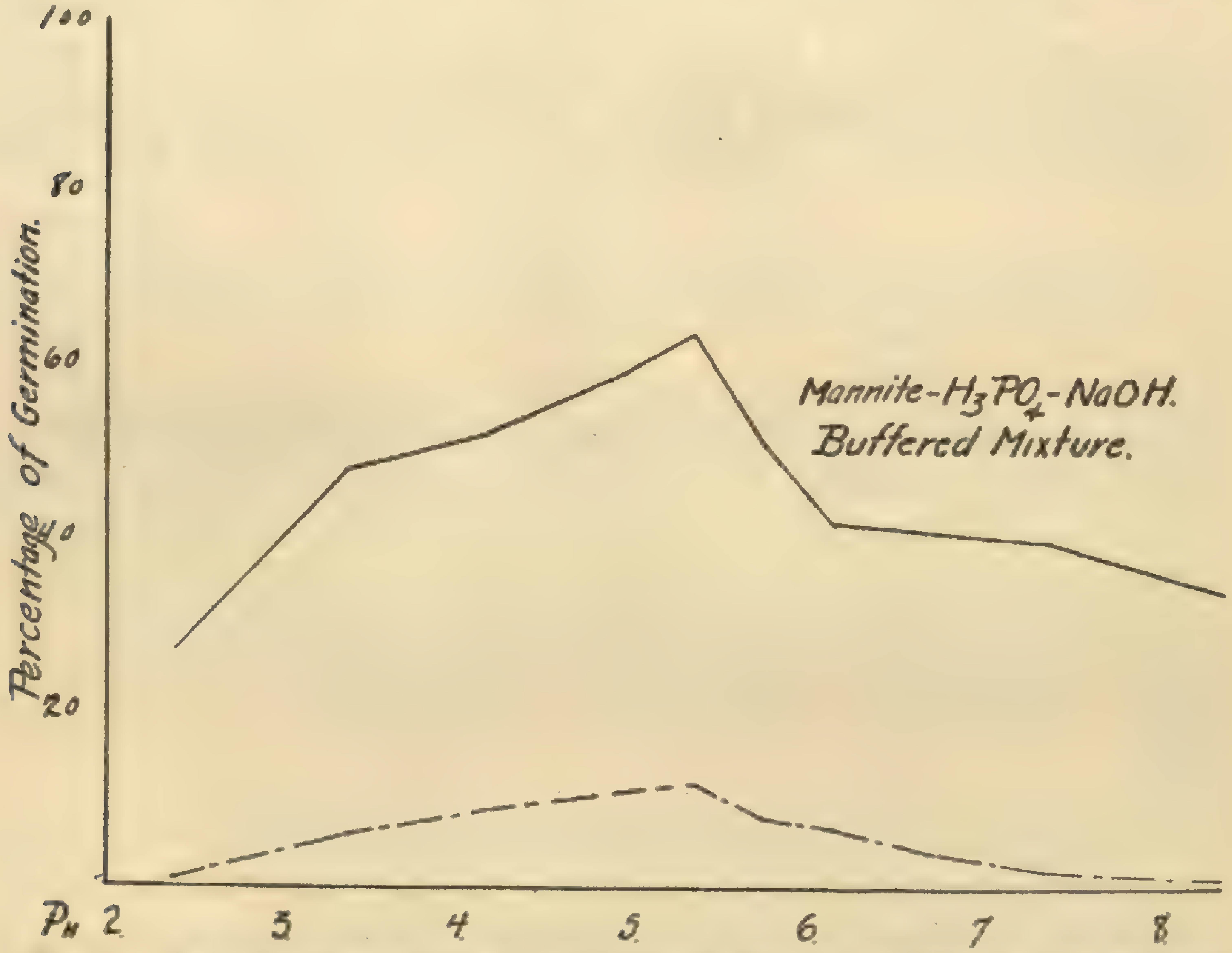

Fig. 2. Germination of spores of *Gloeosporium venetum* in hanging-drop cultures: toxic action of colloidal sulphur prepared by method 1 — - —; control, without sulphur ————.

The results show that the concentration of the sulphur employed in the culture solutions was a very important factor. The organisms tested vary greatly in their resistance to the toxicity of this form of colloidal sulphur, *Macrosporium sarcinaeforme* being very resistant, while extremely weak dilutions are sufficient to kill *Sclerotinia cinerea*. In general, this form of sulphur is most toxic toward, and in, the alkaline range of hydrogen-ion concentrations. The highest percentage of germination was in most cases at P_H 3.4. Beyond this point toward the

alkaline range there was a gradual decrease to the point P_H 5.8, after which there is a sharp decrease.

The influence of the hydrogen-ion concentration upon the toxicity of this form of colloidal sulphur differs from the results obtained by Young ('22) with his hydrophilic colloidal sulphur. In order to make a comparison by the same method, hydrophilic

Fig. 3. Germination of spores of *Sclerotinia cinerea* in hanging-drop cultures: toxic action of certain forms of colloidal sulphur; prepared by method 1 — - —; prepared by method 2 - - - - - -; control, without sulphur ————.

colloidal sulphur was prepared according to the method of Young ('22) which was as follows: Fifty gms. of pure crystalline sodium thiosulphate were dissolved in 30 cc. of distilled water; 70 gms. of concentrated H_2SO_4, sp. gr. 1.84, arsenic-free, were weighed into a glass cylinder of 300 cc. capacity. The cylinder was placed in a vessel of cold water, and the saturated solution of sodium thiosulphate added very slowly with occasional stirring. The mixture was then allowed to cool, and 30 cc. of distilled water were added. The preparation was then placed in a water bath and warmed to 80° C. for 10 minutes and filtered through glass

wool to remove insoluble sulphur. After the mixture was allowed to cool, concentrated NaCl was added and the mixture centrifuged for 30 minutes at 1500 revolutions per minute. The coagulum was then peptized with 100 cc. of distilled water and the insoluble sulphur centrifuged out. The peptized sulphur was then treated 3 times with 25 cc. of saturated NaCl and finally peptized by adding 1 gm. of the coagulum to 100 cc. distilled water. The solution had a P_H of 4.2 ,which does not change upon standing.

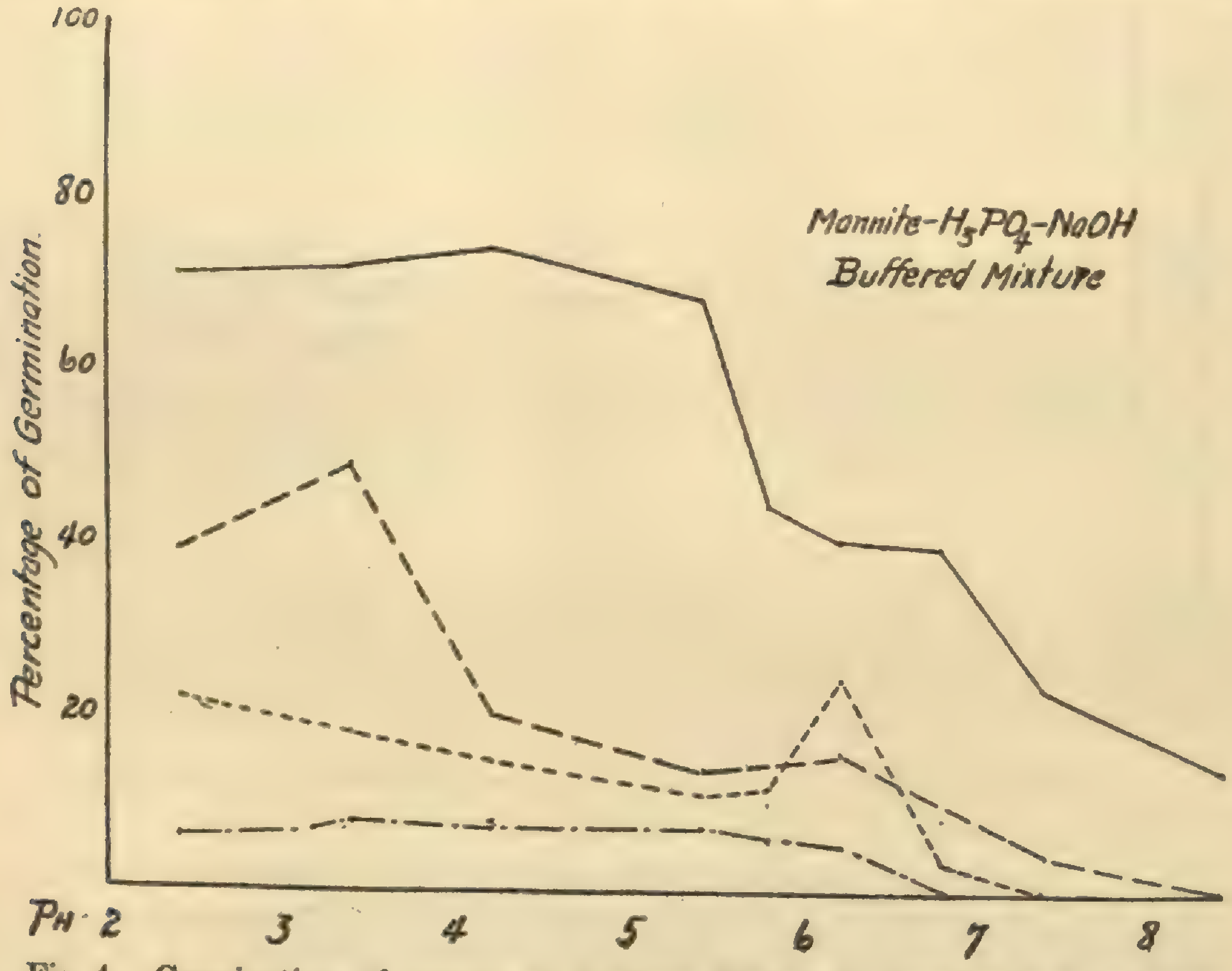

Fig. 4. Germination of spores of *Ustilago Hordei* in hanging-drop cultures: toxic action of certain forms of colloidal sulphur; prepared by method 1 - — - —; prepared by method 1, crystallized — — —; prepared by method 2 - - - - -; control, without sulphur ———.

By means of an accurately calibrated pipette, aliquot parts were measured into each of 10 tubes containing the slightly buffered solution, to make the dilutions indicated in table III. The hanging-drop cultures were made in exactly the same way as described for the other forms of colloidal sulphur, and germination counts were made after an incubation interval of 18 hours at 23° C. The results are shown in table III and in figs. 1, 3, and 4.

TABLE III

TOXICITY OF CERTAIN SULPHUR SUSPENSIONS. THE FIGURES REPRESENT PERCENTAGE OF GERMINATION (AVERAGE OF 2–5 TESTS)

Organism	Form of colloidal sulphur	Dilution of sulphur	Hydrogen-ion concentration (P_H)									
			2.4	3.4	4.2	5.0	5.4	5.8	6.2	6.8	7.4	8.4
Botrytis Alii	Control, without sulphur		59	81	82	71	70	51	38	8	2	0
	Prepared by Method 1	1–2,000	9	14	12	9	5	2	1	0	0	0
	Prepared by Method 2	1–2,000	0	0	0	0	0	0	0	0	0	0
Botrytis cinerea	Control, without sulphur		72	83	80	—	74	57	47	18	6	0
	Prepared by Method 1	1–2,000	16	27	20	—	19	10	7	0	0	0
	Prepared by Method 1, sulphur crystallized	1–1,000	75	81	78	—	58	—	36	—	5	0
	Prepared by Method 2	1–4,000	0	0	0	—	0	—	0	—	0	0
		1–8,000	22	18	15	—	11	12	19	18	6	0
Colletotrichum Gossypii	Control, without sulphur		48	59	65	—	78	54	40	22	13	7
	Prepared by Method 1	1–10,000	2	15	16	—	16	17	14	14	9	4
Gloeosporium venetum	Control, without sulphur		27	48	52	59	64	51	42	41	40	3.4
	Prepared by Method 1	1–2,000	0	0	0	2	0	0	0	0	0	0
		1–4,000	1	6	9	11	12	8	7	4	2	1
	Prepared by Method 2	1–4,000	0	0	0	0	0	0	0	0	0	0

TABLE III (Cont'd.)

Organism	Form of colloidal sulphur	Dilution of sulphur	Hydrogen-ion concentration (P_H)									
			2.4	3.4	4.2	5.0	5.4	5.8	6.2	6.8	7.4	8.4
Macrosporium sarcinaeforme	Control, without sulphur		17	90	94	97	94	93	93	90	83	75
	Prepared by Method 1	1–500	1	21	22	25	29	27	27	18	19	20
Sclerotinia cinerea	Control, without sulphur		53	56	59	57	56	50	28	20	2	0
	Prepared by Method 1	1–10,000	0	0	0	0	0	0	0	0	0	0
		1–20,000	1	7	6	5	4	2	1	1	0	0
	Prepared by Method 2	1–20,000	0	3	6	—	2	1	1	0	0	0
Ustilago Hordei	Control, without sulphur		71	72	73	—	68	44	40	39	23	14
	Prepared by Method 1	1–1,000	6	8	7	—	7	6	5	0	0	0
	Prepared by Method 1, sulphur crystallized	1–1,000	39	49	20	—	14	—	16	—	4	—
	Prepared by Method 2	1–2,000	22	18	15	—	11	12	24	3	0	0

In the table and figures just referred to, the form of colloidal sulphur is indicated according to the method of its preparation. Thus, Method I refers to the colloidal sulphur prepared by the SO_2-H_2S process, and Method 2 refers to the hydrophilic form of colloidal sulphur prepared with sodium thiosulphate and H_2SO_4.

The results of the toxicity tests of the two forms of colloidal sulphur show that Young's hydrophilic form is much more toxic to the organisms used, as it required much smaller quantities of this form to inhibit germination of spores. This toxicity corresponds to the size of the sulphur particles. It has already been indicated that the form prepared by the SO_2-H_2S method is largely the hydrophobic form with probably a small amount of the hydrophilic form.

The influence of the hydrogen-ion concentration upon the hydrophilic colloidal sulphur was found to be essentially the same as that recorded by Young ('22). Upon examining the culture tubes containing the hydrophilic colloidal sulphur, it was also found that settling out was rapidly increased as the P_H increased beyond P_H 5.4. However, this does not explain the difference in toxicity of the two forms. It appears logical that if the toxic substance, exhibited by the colloidal sulphur prepared by the SO_2-H_2S method, is pentathionic acid ("truly 'soluble' sulphur") it would be precipitated at a higher P_H than 5.4, as has been shown to be the case with hydrophilic colloidal sulphur. Further proof that pentathionic acid would be precipitated, particularly in the more alkaline solution, is shown by the investigations of Wackenroder ('46), Shaw ('83), Débus ('88), and others. Therefore, it is shown conclusively that the toxic substance exhibited by the form of colloidal sulphur prepared from SO_2 and H_2S possesses properties different from the toxic substance exhibited by the hydrophilic form, prepared according to the method of Young. From the evidence, the latter is, in all probability, pentathionic acid.

There were some indications that the toxic substance exhibited by the colloidal sulphur prepared from SO_2 and H_2S may be destroyed by repeating the coagulation, centrifuging, etc., several times. This remains to be established by more detailed study.

It was later found that when colloidal sulphur was prepared by the SO_2-H_2S method, coagulated with NaCl, and kept for some time in coagulated form, the sulphur soon crystallized and would no longer remain in suspension when water was added. Suspensions were made of this crystallized sulphur and tests were made in the usual way with *Botrytis cinerea* and *Ustilago Hordei*. The results of these tests, in table III, show that the toxic substance has been destroyed to a large extent.

THE INFLUENCE OF THE HYDROGEN-ION CONCENTRATION UPON THE STABILITY OF COLLOIDAL SULPHUR SUSPENSIONS, AND THE RESULTING EFFECT UPON THE TOXICITY

Since it was shown in the toxicity tests that the form of colloidal sulphur prepared by the reaction of SO_2 and H_2S exhibits its greatest toxicity at a higher P_H than 4.2, it was considered important to determine whether the hydrogen-ion concentration has any influence upon the stability of the suspension. A colloidal sulphur dispersion was prepared by the SO_2-H_2S method, coagulated with NaCl and centrifuged. The coagulum was then weighed and taken up with distilled water, in the proportion of 1 gm. of sulphur to 200 cc. of water. Fifty-cc. portions of the suspension were measured into each of 11 beakers. The P_H of the suspension was 4.2. The suspensions were then adjusted towards, and into, the alkaline range with M/10 Na_2HPO_4, and on the acid side with M/10 H_3PO_4. The resulting preparations had the following range of hydrogen-ion concentrations: P_H beyond the acid range, 2.4, 3.2, 4.2, 5.0, 5.4, 5.8, 6.2, 6.8, 7.4, and 8.4. The acid solution was adjusted slightly beyond the acid range of available indicators. Portions of these solutions were transferred to clean test-tubes, and the tubes were closed with corks. The remaining portions were used in the subsequent experiment.

The suspensions showed a very striking range in stability. Settling out of the sulphur was increased rapidly as the P_H increased beyond 5.8. A photograph of the tubes was made after 8 months and is shown in pl. 20. The stability of the preparations was as follows: P_H 8.4 began to aggregate and settle in about 1 week and had settled out completely in 2 weeks. P_H 7.4

settled out in 3 weeks. P_H 6.8 settled out in 4 weeks. P_H 6.2 had settled out to a large extent after 7 weeks. P_H 5.8 changed from a bright yellow to cream-white in about 8 weeks, with some settling out. After 8 months this solution had largely settled, but the photograph does not bring this out clearly because of sulphur particles sticking to the sides of the tubes, which could not be removed without agitation of the solution. The acid solution (that is, the solution which was adjusted beyond the acid range of available indicators) began to settle in about 1 month and continued slowly. There was still some sulphur in the suspension after 8 months, as shown in pl. 20. No great difference was manifest in the stability of the preparations represented by P_H 2.4, 3.2, 4.2, 5.0, and 5.4. There was some sediment in all the tubes after 8 months, but the range from P_H 4.2 to 5.4 shows greatest stability.

The tubes were shaken, and 0.5 cc. were taken from each tube and transferred to tubes containing 10 cc. of the slightly buffered solution of like hydrogen-ion concentration. This gave a final concentration of sulphur of 1 to 4,000 which is weaker than that used for other toxicity tests. Spore suspensions of *Botrytis cinerea* were made from the sulphur suspensions, and germination tests were made in the usual way in closed-ring cells. The results are shown in table IV.

TABLE IV

TOXICITY TESTS WITH CERTAIN FORMS OF COLLOIDAL SULPHUR. THE FIGURES INDICATE PERCENTAGE GERMINATION

Organism	Form of sulphur	Hydrogen-ion concentration (P_H)							
		2.4	3.2	4.2	5.4	5.8	6.2	6.8	7.4
Botrytis cinerea	Control, without sulphur	72	83	80	75	57	47	18	6
	Colloidal sulphur adjusted to P_H range indicated after standing 8 months	24	60	67	47	62	39	29	10

The results of this test show that when the stability of the sulphur is destroyed by a higher P_H than 5.4, the toxic substance is likewise destroyed. In this case there was still some sulphur

in suspension at P_H 5.8. However, it did not exhibit any toxicity to *Botrytis cinerea*. The suspensions referred to as P_H 2.4, 3.2, 4.2, and 5.4 are all toxic even with the very weak concentration of sulphur used.

THE TOXICITY OF VOLATILE PRODUCTS OF COLLOIDAL SULPHUR

Since it was demonstrated by Young ('22) that hydrophilic colloidal sulphur exhibited the usual degree of toxicity when the spores were not in direct contact with the sulphur, it was thought important to determine whether the toxic substance of colloidal sulphur made by the SO_2-H_2S method would be liberated to the same extent. To test this point, portions of the freshly prepared sulphur suspensions, employed in the preceding experiment, were used. These suspensions had been adjusted, as indicated, to the hydrogen-ion concentration range P_H 2.4–8.4.

The organisms used were *Botrytis Alii* and *Ustilago Hordei*. The hanging-drop cultures were made in the usual way, with modifications as follows: A small quantity (one-tenth cc.) of each sulphur suspension was placed in the bottom of each cell. The spores were suspended in the slightly buffered mixture without sulphur. In this way the spores were not in direct contact with the sulphur particles, being separated by the height of the cell, which was 8 mm. The cultures were incubated at 23° C. and germination counts made at the end of 18 hours. The results are given in table v.

TABLE V

TOXICITY OF VOLATILE PRODUCTS FROM CERTAIN COLLOIDAL SULPHUR SUSPENSIONS. THE FIGURES REPRESENT PERCENTAGE GERMINATION

Organism	Form of sulphur	Hydrogen-ion concentration							
		2.4	3.2	4.2	5.4	5.8	6.2	6.8	7.4
Botrytis Alii	Control, without sulphur	59	81	82	70	51	38	8	2
	Colloidal sulphur in bottom of cells	2	5	7	6	4	0	0	0
Ustilago Hordei	Control, without sulphur	71	72	73	68	44	40	39	23
	Colloidal sulphur in bottom of cells	3	19	17	14	12	11	10	4

The results in this table are similar to those recorded in table III. The colloidal sulphur exhibits the usual degree of toxicity, that is, the toxicity was greatest beyond P_H 4.2, with freshly prepared suspensions.

THE EFFECT OF DRYING AND AERATING UPON THE TOXICITY OF COLLOIDAL SULPHUR

Since some growers prefer to use sulphur dusts, rather than spray solutions, a test was made to determine whether colloidal sulphur could be dried without destroying its stability and toxic property. A colloidal sulphur suspension was prepared by the SO_2-H_2S method, was coagulated with NaCl, and centrifuged. One gm. of the coagulum was weighed on to a clean watch-glass, spread over the surface, and allowed to dry thoroughly at room temperature. After 5 days the sulphur was in the form of a very fine powder. The dry sulphur was taken up with 200 cc. of distilled water. The sulphur assumed the colloidal state readily and the resulting suspension had a reaction of P_H 5.0. Toxicity tests were made in the usual way, and the results are recorded in table VI.

Two series of wash bottles were arranged to test the effect of aeration upon the stability and toxicity of colloidal sulphur. Freshly made colloidal sulphur preparations containing 1 gm. of sulphur in 200 cc. of water and having a reaction of P_H 4.0 were transferred to the wash bottles. Series No. 1 was aerated continuously for 5 days. Air from which the oxygen was removed with alkaline pyrogallol[1] was passed through the duplicate series No. 2.

After 5 days the reaction of each sulphur suspension was tested and found to be P_H 1.4 in Series No. 1, and P_H 1.8 in Series No. 2. The hydrogen-ion concentrations were adjusted to P_H 5.0 with M/10 Na_2HPO_4, and toxicity tests were made in closed-ring cells in the usual way. For a comparison a freshly made solution of colloidal sulphur was also tested. Spores of *Sclerotinia cinerea* and *Botrytis Alii* were used as indicators of the toxicity. The results are recorded in table VI. In the table the dilution of sulphur used was 1–20,000 for *Sclerotinia cinerea* and 1–2,000 for *Botrytis Alii*.

[1] One part pyrogallol, 5 parts NaOH, and 30 parts H_2O.

TABLE VI

TOXICITY OF PRE-DRIED AND OF AERATED SULPHUR SUSPENSIONS. THE FIGURES REPRESENT PERCENTAGE OF GERMINATION (AVERAGE OF DUPLICATE CULTURES MADE AT DIFFERENT TIMES)

Organism	Treatment of sulphur				
	Control, without sulphur	Freshly prepared	Air-dried	Aerated $+O_2$	Aerated $-O_2$
Botrytis Alii	71	15	10	2	8
Sclerotinia cinerea	57	8	12	11	7

The results show that drying and continuous aeration for 5 days has no appreciable effect upon the toxicity of this form of colloidal sulphur. Further tests will be required to determine whether there is any influence from more protracted periods of drying and aerating. Likewise, further investigations are necessary to determine what acid or acids are responsible for changing the P_H of the colloidal sulphur solution during the aeration. It was found that the aeration of sulphur "flour" resulted in a change in reaction toward the acid range within a very short time.

THE INFLUENCE OF TEMPERATURE UPON THE TOXICITY OF COLLOIDAL SULPHUR

It has been shown by Doran ('22) that the fungicidal value of sulphur increases with the rise of temperature. Butler ('23) found that the temperature was an important factor in controlling snapdragon rust by the use of sulphur dust. Below 15° C. sulphur was found to be ineffective.

An experiment was arranged to test the influence of a restricted temperature range upon the toxicity of a colloidal sulphur preparation. A suspension containing 1 gm. of colloidal sulphur (SO_2-H_2S form) in 200 cc. of water was freshly prepared. The reaction of this suspension was P_H 4.0. A dilution of 1 to 8,000 was made from this suspension in the slightly buffered solution P_H 4.2. This concentration of sulphur was known not to inhibit germination of spores at ordinary temperature. Toxicity tests were made with spores of *Botrytis cinerea* at the temperatures 18°, 22°, 24°, and 28° C. Controls without sulphur were also

run at the same time. These tests were made in duplicate and conducted at two different times. The results are shown in table VII.

TABLE VII

THE EFFECT OF TEMPERATURE UPON THE TOXICITY OF A COLLOIDAL SULPHUR SUSPENSION. THE FIGURES REPRESENT PERCENTAGE OF GERMINATION

Organism	Form of sulphur	Temperature ° C.			
		19	22	24	28
Botrytis cinerea	Control	67	70	81	40
	Colloidal sulphur	18	22	17	8

Toxicity was exhibited at the lowest temperature tested, though the higher temperatures increased the toxicity to a considerable extent. It would be of importance to test the effect of a wider range of temperatures and with a variety of organisms.

Practical Application

After it was found that colloidal sulphur prepared by the methods herein described was effective in inhibiting the germination of spores of certain economic fungi, as usually tested in the laboratory, it was next necessary to demonstrate the fungicidal value of these materials by practical field applications. Arrangements were made with Dr. L. F. Nickell of the Monsanto Chemical Works, East St. Louis, Ill., for the use of equipment to manufacture a sufficient quantity of materials for field tests.

The materials were prepared according to methods already described, with certain modifications to suit the available equipment. A 500-gallon wooden tub, fitted with a steam coil, agitators, cover, and a flue provided with a steam jet were used for the purpose.

The hypo-H_2SO method was necessarily modified, since the concentrated H_2SO_4 could not be used in the tub because of the iron agitator and steam coil. The method used was as follows: Seven hundred pounds of hypo were dissolved in 75 gallons of water and the solution warmed with the steam coil to 50° C. Ten pounds of glue were dissolved by means of steam and this

was added to the hypo solution. One hundred pounds of commercial H_2SO_4, sp. gr. 1.84, were added slowly by means of a siphon. The mixture was then adjusted to P_H 4.2 with sulfocide, 1 part to 5 parts of water. The agitator was kept in motion during the entire process.

The lime sulphur method was slightly modified as follows: Commercial lime sulphur solution was diluted with 4 parts of water and the mixture warmed to 40° C. Ten pounds of glue, previously dissolved by means of steam, were added for each 100 gallons of the diluted lime sulphur. The reaction of the lime sulphur mixture was then adjusted to P_H 4.2 with HNO_3, 1 part to 20 parts of water. The agitator was kept in motion throughout the process. It was originally planned to allow the mixture to set over night with the agitator in motion in order to free the mixture of H_2S. Due to the short interval of time to which the writer was restricted in the use of the apparatus, another and more rapid method was used to eliminate the H_2S. Therefore, the mixture was heated to 70° C. and aerated several hours by means of an air pump. This aeration and heating unfortunately destroyed the stability of the solution to a considerable extent. Additional quantities of the mixture were prepared in a similar way by using 1 to 20 H_2SO_4.

The materials thus prepared were sent to the Missouri Agricultural Experiment Station, and to Adams and Chester Counties, Pennsylvania, to be used in tests being made for the control of apple diseases. Mr. R. C. Walton, of the Pennsylvania Agricultural Experiment Station, had charge of the field tests in Pennsylvania.

Due to the seasonal conditions very little disease appeared in the apple orchard at the Missouri Station. Therefore, no comparative results of value were obtained.

The results of the tests conducted in the commercial orchards of Pennsylvania were very favorable, particularly in the case of the preparation made from lime sulphur. These materials gave very efficient control of apple scab, a disease which was severe in Pennsylvania during that season. The details of these results will presumably be published separately (Walton, '26). The injury to foliage and fruit was a minimum in the plots sprayed

with these materials. The writer observed these plots in the late summer, and it was then evident that the foliage of the trees sprayed with the mixture prepared from lime sulphur and HNO_3 was of a much darker green color. Furthermore, the growers found the use of these materials satisfactory because of the ease of handling and applying.

Colloidal sulphur was made in the laboratory by the SO_2-H_2S method for field tests. The method used was the same as has already been described except that a 10-gallon glass carboy was used as a reaction tank for the SO_2 and H_2S. Large earthenware jars (especially made for the Chemical Department, Washington University) were used for H_2S generators. The product produced by this method was sent to the Michigan, Missouri, and New York Agricultural Experiment Stations, and to Adams County and Chester County, Pennsylvania, for field tests.

The results of these tests were not so promising as was anticipated, due probably to two factors: (1) The dilution of the sulphur used was probably too great; and (2), as has already been indicated, the sulphur crystallized in a short time after it was prepared. The technique of large-scale preparation, therefore, requires further detailed study.

Conclusions

1. Methods have been devised for preparing promising colloidal sulphur suspensions for use in practical spraying.

2. The stability of colloidal sulphur preparations was found to depend upon the method of mixing the chemicals, the temperature of solutions, and upon the introduction of protective colloids.

3. Of the emulsoid colloids that it has been practicable to employ, glue has proved to be the most effective in preserving the stability of colloidal sulphur suspensions.

4. The use of weak alkalies in adjusting suspensions prepared from hypo and H_2SO_4 was found necessary; and for this purpose Na_2CO_3 and Na_2HPO_4 gave the best results.

5. In preparing colloidal sulphur from lime sulphur, weak, rather than strong, solutions of HNO_3 and H_2SO_4 were more satisfactory.

6. The colloidal sulphur mixtures prepared by the methods

devised in the course of this work were found to be toxic to all forms of fungi tested under laboratory conditions.

7. Greenhouse tests with a variety of plants have shown that the products spread well and that they adhere to the foliage; at the same time they do not cause injury under the conditions tested.

8. Colloidal sulphur freshly prepared from SO_2 and H_2S was effective for the control of carnation rust in the greenhouse.

9. It would seem to be demonstrated that the toxicity of different forms of colloidal sulphur may be ascribed to different toxic substances. The properties of the toxic substances exhibited by colloidal sulphur prepared from SO_2 and H_2S are different from the toxic substance (pentathionic acid) exhibited by Young's hydrophilic colloidal sulphur.

10. There is a gradual increase in toxicity of colloidal sulphur formed from SO_2 and H_2S, beginning at P_H 4.2 and continuing to P_H 5.4, while at higher P_H values there is a rapid increase. Young's hydrophilic colloidal sulphur exhibits the greatest toxicity in the range P_H 4.2 to 5.4.

11. Colloidal sulphur prepared from SO_2 and H_2S in paste form will crystallize in about 1 month. This crystallization destroys the toxic property.

12. Colloidal sulphur preparations have greatest stability between P_H 3.0 and 5.4. The loss of stability is accompanied by a destruction of the toxic property.

13. The toxic constituent of colloidal sulphur, when freshly prepared from SO_2 and H_2S, is slightly volatile and is liberated most rapidly at a higher P_H than 4.2.

14. Desiccation and aeration do not destroy the stability or the toxic component of colloidal sulphur prepared from SO_2 and H_2S.

15. Colloidal sulphur prepared from SO_2 and H_2S is most toxic at higher temperatures.

16. When manufactured for field spraying tests the methods for preparing colloidal sulphur were modified to suit the equipment available. Prepared in this way, certain of the products gave excellent control of apple scab during the summer of 1924.

The writer takes great pleasure in extending thanks for many suggestions and criticisms to Dr. B. M. Duggar, who directed the work; to Dr. H. C. Young, of the Ohio Agricultural Experiment Station for many suggestions; to Dr. George T. Moore, for the privileges and facilities of the Missouri Botanical Garden; and to the Crop Protection Institute for the necessary funds and materials.

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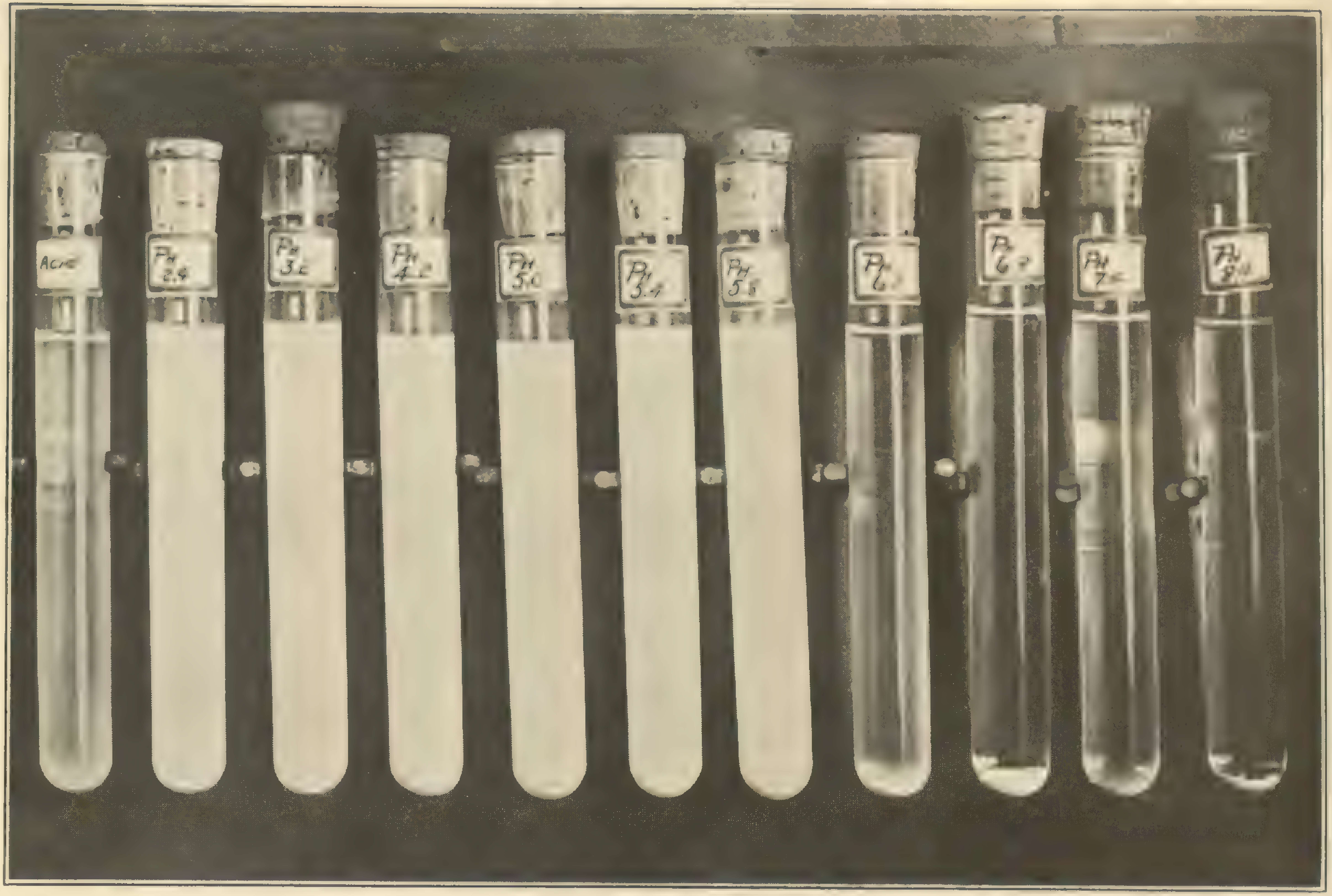
Explanation of Plate

PLATE 20

Effect of the hydrogen-ion concentration (P_H) upon the stability of colloidal sulphur solution.



TISDALE—COLLOIDAL SULPHUR

GENERAL INDEX TO VOLUME XII

New scientific names of plants and the final members of new combinations are printed in **bold face** type; synonyms and page numbers having reference to figures and plates, in *italics;* and previously published scientific names and all other matter, in ordinary type.

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